Hydrogeology of the Green River Lowland and Associated Bedrock Valleys in Northwestern Illinois

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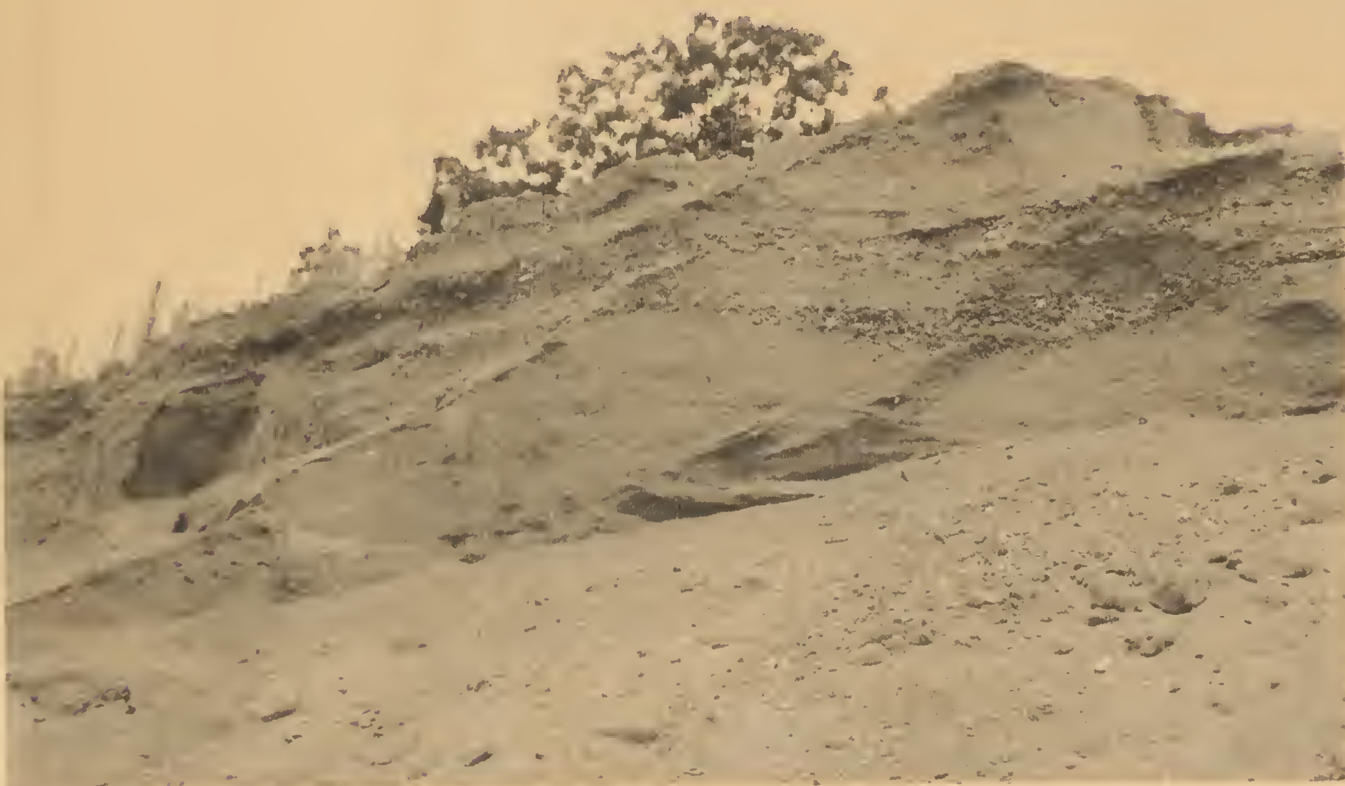

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Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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Cover photo Exposure of the surficial sand and gravel (Henry Formation) in the Green River Lowland.

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ABSTRACT

Groundwater from drift aquifers in the Green River Lowland of northwestern Illinois is important to the region's agricultural economy. Previous investigations of the groundwater resources of this area examined the drift aquifers in terms of the possible occurrence of sand and gravel. This report presents a more definitive characterization of these aquifers.

Two major aquifers occur in the Quaternary sediments found in the Green River Lowland. Surficial deposits of sand and gravel cover much of the Green River Lowland and comprise an unconfined aquifer herein named the Tampico aquifer. These deposits are typically about 50 feet thick. Sand and gravel deposits buried within the Princeton Bedrock Valley are part of a system of bedrock valley aquifers that extends beyond the boundaries of the Green River Lowland. Consequently, this report also includes the Princeton, Paw Paw, and Rock Bedrock Valley aquifers. Thickness of the bedrock valley aquifers exceeds 150 feet. An interval of fine grained sediments that is generally 25 to 50 feet thick separates the Tampico aquifer from the deeper Princeton Bedrock Valley aquifer. Where these sediments are absent on the west side of the Lowland, the two aquifers form one hydraulic unit.

The bedrock valley aquifers are a relatively untapped groundwater resource in the area of the Green River Lowland. The Tampico aquifer has a high potential for groundwater contamination because sand and gravel occurs at the land surface. The hydraulic connection between it and the Princeton Bedrock Valley Aquifer is an important consideration in developing strategies for protecting groundwater from contamination by sources near or at the land surface.

INTRODUCTION

Irrigated cropland is a major component of the agricultural industry in the Green River Lowland (Bowman 1991), a broad sand plain located in northwestern Illinois (fig. 1). Drift aquifers are the principal water source for the irrigation. The combination of irrigable soils and a significant groundwater resource should foster further development of irrigation in the Green River Lowland.

Although groundwater is very important to the local agricultural economy, the hydrogeologic characteristics of the Quaternary deposits in the Green River Lowland are not very well known.

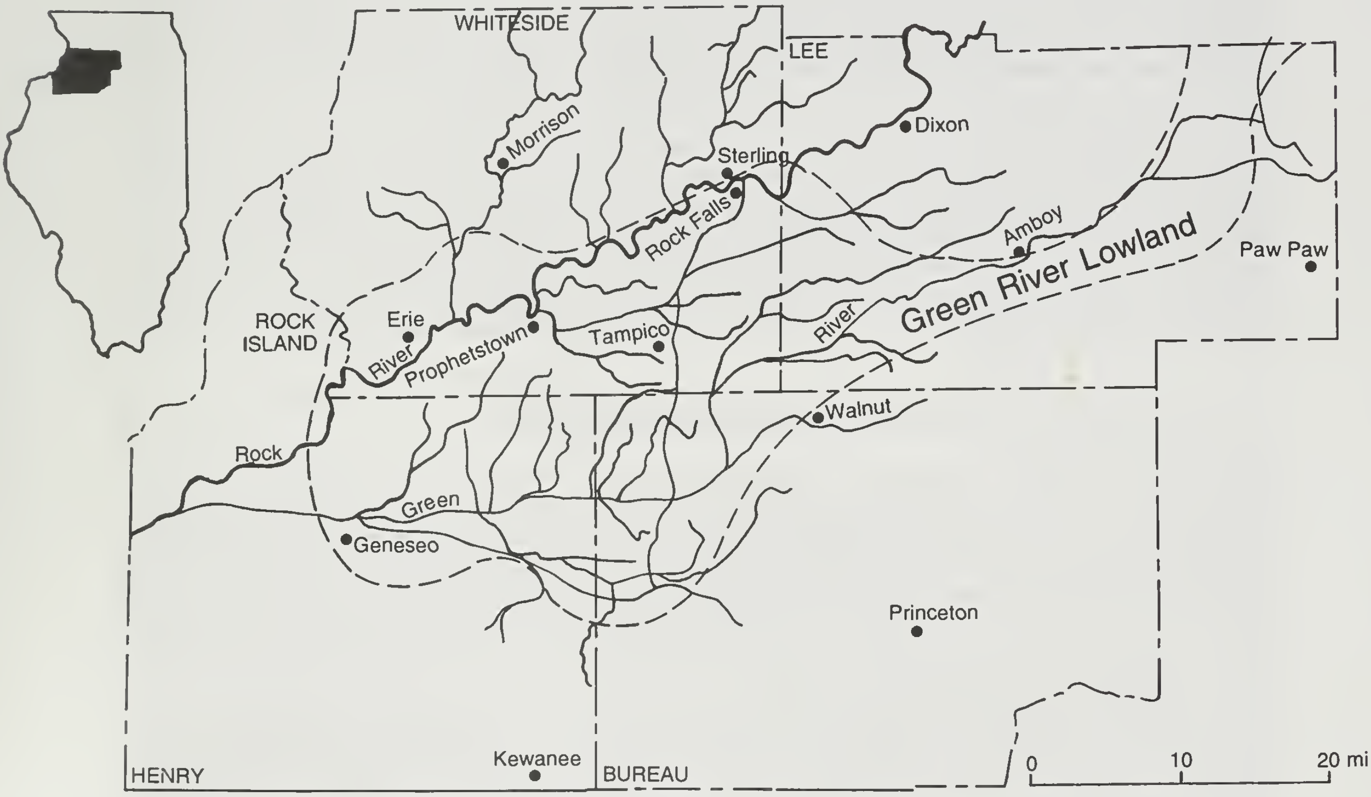


Figure 1 Location of the Green River Lowland.

Previous studies of the groundwater resources of the Lowland examined the drift aquifers in terms of the possible occurrence of sand and gravel. Better definition of these characteristics is needed to integrate effectively the assessment, management, and protection of groundwater resources in this part of Illinois.

The drift aquifers in the Lowland include a surficial, unconfined aquifer that underlies much of the Lowland and a deeper aquifer found within the Princeton Bedrock Valley. The Princeton Bedrock Valley is part of a larger system of buried bedrock valleys that extends beyond the Lowland and includes the Paw Paw and Rock Bedrock Valleys (plate 1). This report includes a discussion of each of the deep, drift aquifers found in these three bedrock valleys.

This report is part of a cooperative study with the Illinois State Water Survey (ISWS) of the hydrogeology of the Green River Lowland. Water well records on file at the Illinois State Geological Survey (ISGS) and previous studies were used to delineate the depth, thickness, and areal extent of the principal drift aquifers in the Lowland. The report identifies the susceptibility of these aquifers to contamination from sources at land surface. Data from existing well records and previous studies were verified by the results of additional test drilling undertaken by the ISWS. The ISGS sponsored drilling one of the ISWS test holes in Bureau County into bedrock. The data from the additional test drilling will be presented in a future cooperative report.

The elevation datum used in this report is the National Geodetic Vertical Datum of 1929 (NGVD), commonly referred to as "mean sea level."

PREVIOUS INVESTIGATIONS

The potential existence of a significant groundwater resource from sand and gravel aquifers in the Green River Lowland has been long recognized (Mead 1894, also Leverett 1896, 1899), but a more complete understanding of this resource developed only as subsurface data became available from water well records. Horberg (1950) established the regional topography of the bedrock surface and named the various bedrock valleys. He also correlated the pre-Illinoian sand and gravel deposits in the Princeton Bedrock Valley with the Sankoty Sand (see also Horberg et al. 1950). Bergstrom (1956), Foster (1956), Hackett and Bergstrom (1956), and Hanson (1955) further described the groundwater resource potential of the Lowland as part of regional groundwater resource studies. Foster (1956) and Hanson (1955) focused on the bedrock and glacial drift aquifers in Lee and Whiteside Counties. Bergstrom et al. (1968) presented an overview of the groundwater resources in the Quaternary deposits of Illinois. They noted the textural variations between the pre-Illinoian and the younger sand and gravel deposits in the Princeton Bedrock Valley.

Piskin and Bergstrom (1975) described the thickness and character of the glacial drift on a regional basis. This helped establish the framework for characterizing the hydrogeologic setting of the glacial drift deposits. Anderson (1967, 1968) described the effects of glaciation on an area that included the Green River Lowland. McGinnis and Heigold (1974) studied a closed depression in the floor of the Princeton Bedrock Valley found near the northwest side of the Lowland (plate 1). Their report suggests that the floor of the bedrock valley underlying the Lowland may not be as uniformly graded as modern stream valleys. It also suggests the possibility that other such depressions may occur elsewhere along the valley.

OCCURRENCE AND QUALITY OF GROUNDWATER

General Concepts

The sand and gravel aquifers of the Green River Lowland region are principally recharged by precipitation. Part of the precipitation that falls to the ground returns directly to the atmosphere through evaporation, part of it runs off into streams, and the rest percolates into the soil. Some of the soil water evaporates directly or is transpired by plants. Water in excess of the maximum retention capacity of the soil infiltrates downward through pore spaces to the zone of saturation where it enters the groundwater flow system. Interconnected macropores within the soil may provide a more direct path for groundwater recharge.

Groundwater moves from areas having higher hydrostatic pressure (recharge areas) to areas having lower hydrostatic pressure (discharge areas) as a consequence of gravity and pressure. This movement is rather slow, typically on the order of tens to several hundreds of feet per year. The rate of groundwater movement is governed by the hydraulic conductivity of the material through which

the water moves and by the prevailing hydraulic gradient. The magnitude of hydraulic conductivity depends on the grain size distribution of the sediment and the nature and extent of secondary permeability features such as fractures. Saturated deposits with relatively large hydraulic conductivities readily transmit groundwater and constitute aquifers; deposits with relatively small hydraulic conductivities restrict groundwater movement and are defined as aquitards or confining units. Hensel (1992) gives a more in-depth description of natural recharge in Illinois.

Changes in the amount of water stored in an aquifer are caused by changes in the rate of recharge to or discharge from the aquifer and induce water level fluctuations in wells completed in that aquifer. Pumping of wells, earthquakes, and changes in atmospheric pressure or aquifer loading may generate water level fluctuations, particularly in wells screened in a confined aquifer.

Shallow, unconfined aquifers are usually recharged by direct infiltration of precipitation, melting snow, or runoff in spring, early summer, and fall. This is the time when soil moisture is in excess of evapotranspiration requirements. Confined aquifers are recharged more slowly by water moving through the fine grained sediment of the confining beds.

Water Quality

Groundwater contains dissolved mineral matter that is acquired initially as precipitation falls through the atmosphere and later as the water moves through the soil and sediments underlying the land surface. Dissolved minerals vary in type and concentration primarily because of the composition and solubility of the various deposits the water encounters and the length of time the water is in contact with these deposits. Temperature, pressure, and acidity also affect dissolution rates and concentrations of the dissolved minerals. Longer residence time in the subsurface generally results in greater concentrations of dissolved minerals in groundwater. The suitability of groundwater for various uses is determined mostly by the type and concentration of the various chemical constituents present and, to a lesser extent, by the water's physical properties (e.g., temperature, color, and turbidity).

Aquifer Properties

The water yielding capability of an aquifer is characterized by its hydraulic conductivity and storativity. Hydraulic conductivity is a measure of the capacity of an aquifer to transmit groundwater. Storativity is a measure of the quantity of water available from an aquifer. Storativity for an unconfined aquifer is referred to as specific yield. The transmissivity of an aquifer equals the hydraulic conductivity times the saturated thickness of the aquifer. These aquifer parameters, together with water level data, are used to estimate the volume of water stored in an aquifer. The potential yield of a well can be assessed from the hydraulic properties of the aquifer, measurements of hydrostatic head, and well completion data.

Values of hydraulic conductivity, transmissivity, and storativity can be derived two different ways. These parameters can be quantified through analysis and interpretation of aquifer test data. They can also be derived through the interpretation of lithologic descriptions gathered in a test drilling program and by measuring water levels in observation wells. Depending on the intrinsic heterogeneity of the deposits, the results of either of these two methods may be valid only for a comparatively small portion of the total aquifer volume.

DESCRIPTION OF STUDY AREA

Location

The area of this study was the Green River Lowland (fig. 1). Although the Green River Lowland includes parts of seven counties in northern Illinois, the study focused on that part of the Lowland found in southern Whiteside, southwestern Lee, northwestern Bureau, northeastern Henry, and eastern Rock Island Counties. This area encompasses about 800 square miles. The small part of the Green River Lowland located in southeast Ogle County and the west-central edge of De Kalb County was not included.

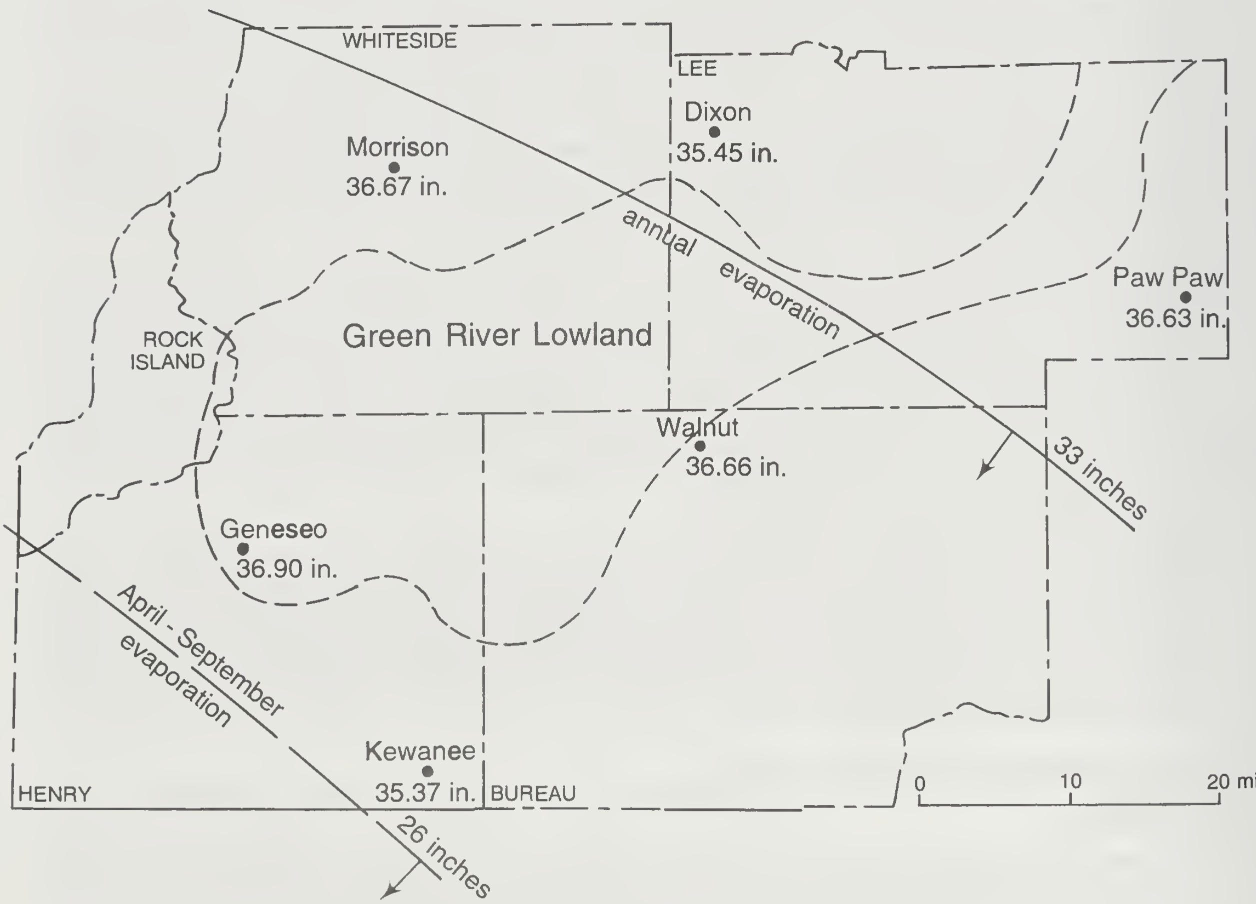
The study also included the Princeton Bedrock Valley, which underlies the Green River Lowland. Because the Princeton Bedrock Valley is part of a more extensive system of bedrock valleys (plate 1), the study included the valleys that extend northwest and southeast from the Lowland (the Princeton Bedrock Valley) and that lie to the east of the Lowland (the Paw Paw and Rock Bedrock Valleys).

Climate

The climate of northwestern Illinois is humid continental (Koeppe 1935) and characterized by warm and wet summers, cold and relatively dry winters, and wide fluctuations in both precipitation and temperature. The inconstancy of the weather patterns arises from the interactions of air masses moving across Illinois from the polar region, the Pacific Ocean, and the Gulf of Mexico.

As is characteristic of a continental climate, the occurrence and distribution of precipitation varies seasonally. Spring precipitation typically covers areas larger than that covered by summer precipitation. Summer rainfall is mostly from thunderstorms or larger storm cells associated with frontal systems. Most of the annual precipitation in the study area falls during the spring and summer months (fig. 2).

Climate data are available for six weather stations located near the perimeter of the Green River Lowland (table 1). Normal annual precipitation for these six stations ranges from 35.37 inches at Kewanee 1E to 36.90 inches at Geneseo (fig. 2), a difference of 1.53 inches. About two-thirds of the normal annual precipitation arrives between April and September. These are the months of plant germination and growth as well as the time during which the rate of evapotranspiration peaks. Normal April–September precipitation varies by 1.49 inches, from 22.82 inches at Kewanee 1E to



Morrison 36.67 in. Weather station
1961-1990 normal annual precipitation

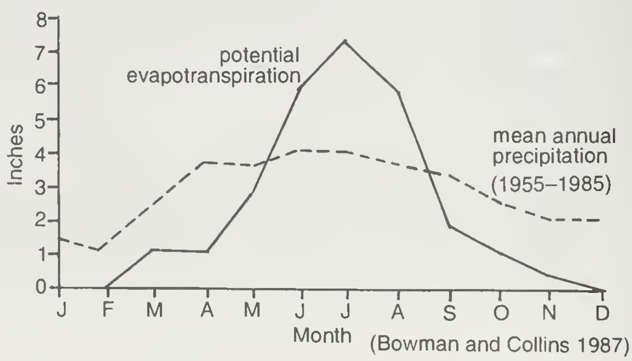


Figure 2 Precipitation-evaporation characteristics of the Green River Lowland area (Neely and Hester 1987, Bowman and Collins 1987).

Table 1 Precipitation readings (in inches) for six weather stations, Green River Lowland area.

Station	Normal annual	Normal April–Sept.	Normal Oct.–March	Highest annual 1961–1990	Lowest annual 1961–1990
Dixon 1NW	35.45	23.24	12.21	47.53 (1965)	22.99 (1976)
Geneseo	36.90	24.31	12.59	51.45 (1990)	22.04 (1988)
Kewanee 1E	35.37	22.82	12.55	51.20 (1970)	22.30 (1988)
Morrison	36.67	23.79	12.88	51.38 (1973)	23.95 (1988)
Paw Paw 1E	36.63	24.19	12.44	49.39 (1965)	23.54 (1976)
Walnut	36.66	24.15	12.51	51.76 (1990)	24.11 (1989)

Precipitation normals are the averages for the 30-year period from 1961 to 1990.

24.31 inches at Geneseo (table 1). Rain or snow falling during the months of October through March can have a greater affect on groundwater recharge than does April–September precipitation. During this time period, water losses resulting from evapotranspiration are at a minimum. Normal October–March precipitation varies from 12.21 inches at Dixon 1NW to 12.59 inches at Geneseo, a difference of 0.38 inches (table 1).

The values for the highest and lowest total annual precipitation in the current normal period of 1961 to 1990 (table 1) suggest the extent of the variability of the precipitation that needs to be included in any hydrological analysis of the Green River Lowland. The greatest amount of yearly precipitation from 1961 to 1990 was reported at Walnut. It received 51.76 inches in 1990 or 15.10 inches above its normal annual precipitation of 36.66 inches. The least amount of yearly precipitation during the same time period was reported at Geneseo. It received 22.04 inches in 1988 or 14.86 inches below its normal annual precipitation of 36.90 inches. These two stations represent a difference of 29.72 inches in total annual precipitation.

Temperature is an important factor in groundwater recharge because it affects the movement of water through the soil profile. The freeze-free period can be defined as the number of days between the last occurrence of 32°F in the spring and the first occurrence in the fall. This period approximates the length of the growing season. During this time, the rate of groundwater recharge is relatively low because water losses through evapotranspiration are high. The length of this period is approximate because frost in the soil profile can remain beyond the last occurrence of 32°F in the spring, and heat from the subsurface can delay freezing of soil moisture in autumn. Movement of water through the soil profile to the zone of saturation typically does not occur if the moisture in the soil profile is frozen. Temperatures may not be low enough during some winters to freeze the soil profile. Under these conditions, groundwater recharge from precipitation and soil moisture may occur. The length of the freeze-free period in any given year may vary across the Green River Lowland depending on local climatic conditions.

The amount of precipitation entering the groundwater flow system as recharge is strongly influenced by evapotranspiration. Water moves from the earth's surface to the atmosphere through the process of evapotranspiration, the combined effects of plant transpiration, and direct evaporation of water from the land surface and bodies of surface water. The rate of evapotranspiration responds to a variety of factors related to climate, vegetative cover, the degree of saturation of the soil profile, and the longevity of the water supply available for transpiration and evaporation. The amount of water moving into the atmosphere varies both seasonally, peaking during the summer, and annually. Over most of the Green River Lowland (fig. 2), annual evaporation is more than 33 inches and April–September evaporation is less than 26 inches (Neely and Heister 1986). A comparison of precipitation with evaporation indicates that normal annual precipitation exceeds annual evaporation but that April–September evaporation exceeds normal April–September precipitation. This suggests that little of the precipitation that falls during the growing season is typically available for groundwater recharge. Rainy periods during the summer may reduce or overcome the difference between April–September evaporation and precipitation.

PHYSIOGRAPHIC SETTING AND SURFICIAL GEOLOGIC FEATURES

The Green River Lowland is one of the physiographic subdivisions of the Till Plains Section, Central Lowland Province (Leighton et al. 1948). It is an irregularly wedge-shaped basin oriented roughly northeast to southwest and narrowing to the northeast (fig. 3). The Rock River Hill Country, the Bloomington Ridged Plain, and the Galesburg Plain adjoin the Lowland to the north, east to southeast, and west to southwest, respectively (Leighton et al. 1948).

The Green River Lowland covers about 950 square miles in parts of seven counties (fig. 3). It extends from eastern Rock Island County about 80 miles to western De Kalb County. The land surface slopes from an elevation of 750 to 800 feet in the northeastern part of the Lowland to 580 to 625 feet in the southwestern part, a gradient of approximately 3 feet per mile. The main part of the Lowland, which extends about 40 miles east to west and about 25 miles north to south, covers about 600 square miles.

The surface of the Green River Lowland is an outwash plain with extensive sand dunes, characterized by poorly developed surface drainage (Leighton et al. 1948). The Green and Rock Rivers drain the Lowland. Both rivers flow from northeast to southwest and discharge into the Mississippi River. Drainage of the Lowland has been altered by a system of drainage ditches and by several feeder canals constructed to supply water to the Hennepin Canal. One of the feeder canals originates at the Rock River near Rock Falls. The drainage ditches, which discharge into either the Rock River or the Green River, have enhanced drainage in the Lowland by lowering the water table. A subtle divide across most of the Lowland separates the drainage to the two rivers. The topographic expression of this divide 'may be more noticeable because of the location and extent of the drainage ditches. The drainage divide becomes very pronounced in the Lowland's southwest end, where the land surface rises to elevations in excess of 650 feet, as much as 100 feet above the elevation of the floodplains of the adjoining Green and Rock Rivers.

The Green River originates within the Green River Lowland in northeastern Lee County. It follows a course through the southern part of the Green River Lowland at a gradient of about 2 feet per mile. Most of its course has been channelized to promote rapid drainage of surface water. Only a reach in central Lee County appears to be somewhat meandering.

The Rock River enters the Lowland in east-central Whiteside County near the county line and follows a meandering course along the northwest edge of the Lowland. It discharges from the Lowland in Rock Island County. The Rock River flows about 57 miles across the Lowland, a linear distance of about 38 miles. The gradient of the river is a little more than 1 foot per mile.

Figure 3 Physiographic divisions of Illinois (Leighton et al. 1948).

Prominent sand ridges and dunes in the form of longitudinal dunes with a west-northwest orientation and crescentic, parabolic dunes (Leighton et al. 1948) are common across the Green River Lowland. These landscape features rise to heights of 10 to 65 feet above the surrounding outwash plain. Although some of the sand ridges may be the result of fluvial processes (bars), most are the result of eolian activity.

DATA SOURCES AND COMPILATION

The records of water wells on file with the ISGS are the principal sources of data on the hydrogeology of the Green River Lowland. Logs of engineering and other test borings were used to supplement the well records. Well locations given in the well records were verified by comparing the names of landowners shown on the well logs with the names of landowners for the corresponding tracts in county plat books published over a number of years. The well logs give general lithologic descriptions of the geologic materials penetrated. These descriptions were interpreted in order to place the various units into a hydrostratigraphic framework for glacial drift. The well records provide the information from which the bedrock lithology and elevation, thickness and lithology of the drift units, and an estimate of the hydraulic properties of the various units were determined. Water levels noted in the water well records were used to distinguish various hydrogeologic units. Some well records with unverified locations were used if the information was in agreement with regional geologic trends.

The results of the test drilling sponsored by the ISWS in Lee, Whiteside, and Bureau Counties supplemented the subsurface data from the water well records. Only a few of these test holes were drilled into bedrock; most of them ended in the glacial sediments within the bedrock valleys. Illinois State Geological Survey personnel described the drill cuttings and obtained natural gamma ray logs of the 22 test holes. Samples of the drill cuttings were bagged in 5-foot intervals for later analysis. Data from the ISWS drilling will be fully presented in a future report.

Locations of data points (Appendix) were plotted on topographic base maps at a scale of 1:24,000. Land surface elevation determined from the topographic maps was used to calculate the elevation of the bedrock surface plus the elevation of the top and bottom of the major sand and gravel units present at each point. The base maps were digitized so that they could easily be reduced to a scale of 1:125,000, affording a more manageable map size for contouring. Several cross sections were made.

HYDROGEOLOGIC SETTING

Bedrock Units and Their Hydraulic Properties

The sedimentary rocks directly underlying the glacial drift in the Green River Lowland study area (fig. 4) include Cambrian to Pennsylvanian age strata (table 2). Bedrock of Devonian and Mississippian age is absent. The geology at the bedrock surface is the most complex in the part of the Lowland in Lee County where Cambrian through Ordovician units that dip to the southwest form northwest-southeast-trending bands that parallel the trend of the Sandwich Fault Zone. Silurian bedrock is found over much of the west half of the Lowland. Pennsylvanian strata occur along the south border of the Lowland and as outliers in northwest Bureau and southwest Lee Counties. Foster (1956), Anderson (1980), Brueckmann and Bergstrom (1968), Hackett and Bergstrom (1956), Hanson (1955), Buschbach (1965), Visocky et al. (1985), and Bergstrom (1956) discuss the hydrogeology of these bedrock units.

Cambrian bedrock The oldest bedrock units in the Green River Lowland are the Cambrian strata in northeastern Lee County. The Mt. Simon Formation and the Ironton-Galesville Formation are mainly sandstone, some of which is dolomitic. The other Cambrian lithologies are shale, siltstone, or dolomite with minor sandstone units.

Sandstone forms the principal aquifers in the Cambrian bedrock. Permeability of the sandstone is the major influence on well yields. The other rock types are primarily confining units to the sandstone aquifers (Visocky et al. 1985). Fractures, solution channels, or other secondary permeability features may locally increase the hydraulic conductivity of the confining units sufficiently so that usable quantities of groundwater can be obtained. This is more common where bedrock having these features directly underlies glacial drift.

Ordovician bedrock Ordovician strata occur in the part of the Lowland in Lee County. Willman et al. (1975) classified these rocks into five groups: Prairie du Chien, Ancell, Platteville, Galena, and Maquoketa.

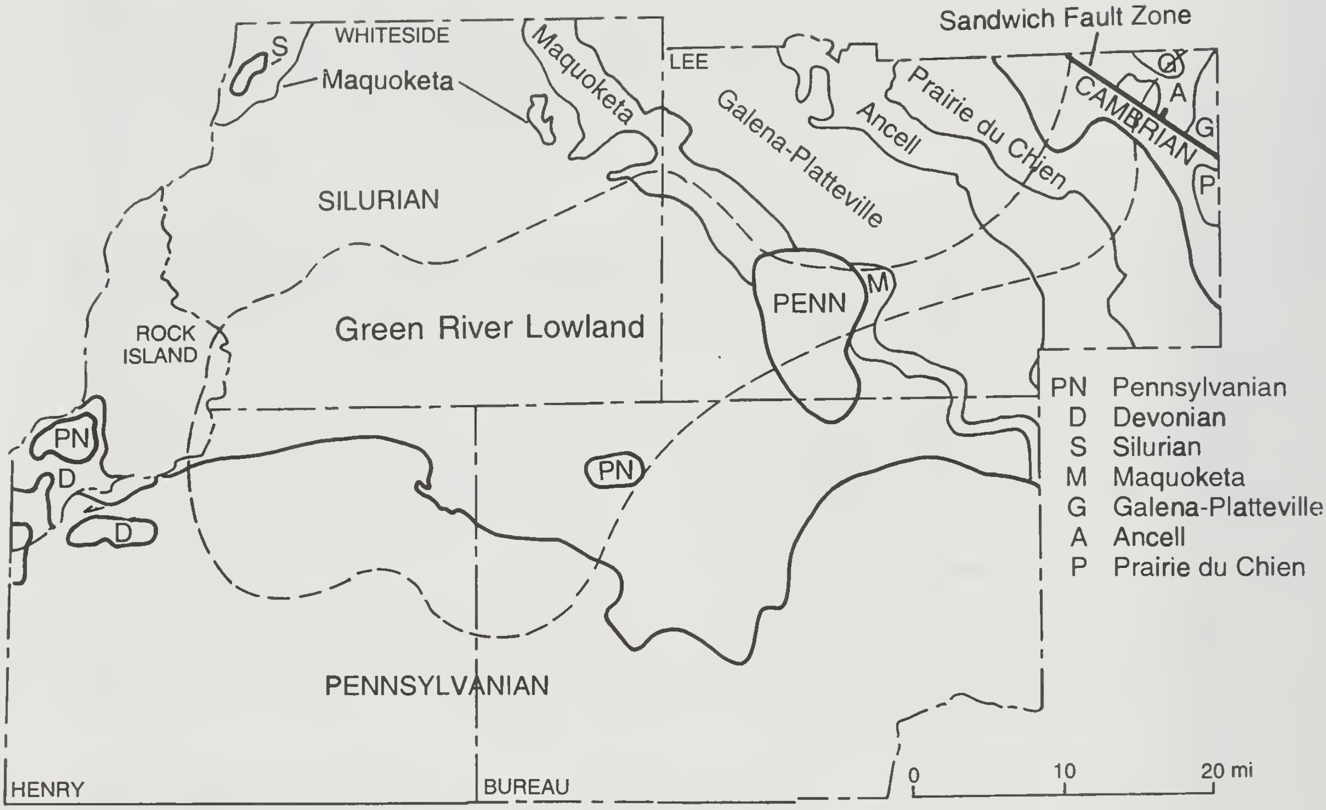


Figure 4 Bedrock geology of the Green River Lowland area (Willman et al. 1967).

The Prairie du Chien Group consists mostly of dolomite and sandstone. Visocky et al. (1985) consider the Prairie du Chien to be a confining unit. The Prairie du Chien may yield relatively small quantities of groundwater from the sandstone and from fractured sandstone or dolomite. Fractures are more common where the Prairie du Chien directly underlies glacial drift (Foster 1956).

The Ancell Group directly overlies the Prairie du Chien and consists mostly of sandstone beds that constitute aquifers. Formation thickness and secondary permeability features control well yield. The St. Peter Sandstone belongs to this group.

The Galena-Platteville Group consists mostly of dolomite and limestone. Groundwater can be obtained from fractures and crevices, but well yields are quite variable. Well yields can be locally significant where the fractured rocks of this group directly underlie glacial drift or occur at or near land surface (Foster 1956).

The Maquoketa Shale Group consists primarily of shale but includes some dolomite units. This group typically is a confining unit (Visocky et al. 1985). Small supplies of water can be obtained from the creviced or fractured dolomite in areas where the dolomite directly underlies glacial drift (Foster 1956).

Silurian bedrock The Silurian strata are predominantly dolomite. Foster (1956) notes that fractures are common within 50 to 100 feet of the bedrock surface and that these fractures can support the low yield of domestic or farm wells. Csallany and Walton (1963) note that the occurrence of joints, fractures, and solution cavities in these rocks varies both vertically and horizontally. The yield of a well is determined by the number of such secondary permeability features it intersects.

Pennsylvanian bedrock Strata of Pennsylvanian age consist primarily of shale and minor amounts of sandstone, siltstone, limestone, and coal. Foster (1956) notes that these units are poor aquifers because fractures are not common in the limestones, and the sandstones are usually tight and discontinuous. Groundwater supplies for domestic or farm wells can be obtained locally where these rocks are fractured and directly underlie the glacial drift. Water moving through the drift is a source of recharge to the fractured rock.

Table 2 Generalized stratigraphic column of bedrock units directly underlying glacial drift, Green River Lowland area (Willman et al. 1975).

System	Group/Formation	Aquifer characteristics
Pennsylvanian	Undifferentiated	Generally not an aquifer; small yields are limited to where fractured rock is recharged by overlying drift
Silurian	Undifferentiated	Mostly carbonates; small yields are possible from solution cavities or fractures; yield depends on how many of these are intersected
Ordovician	Maquoketa Shale Group	Typically confines the underlying aquifer units; small yields are possible where thin, fractured dolomite is recharged by overlying drift
	Galena-Platteville Group	Dolomite with some limestone; well yields are a function of the density of fractures and crevices
	Ancell Group	Mostly sandstone; dependable source of water
	Prairie du Chien Group	Mostly dolomites and sandstone; small yields from the sandstone or fractured dolomite and sandstone
Cambrian	Eminence Fm	Dolomite; small yields may be possible from fractures
	Potosi Fm	
	Franconia Fm	Sandstone and dolomite; small yields may be possible from fractures
	Ironton-Galesville Fm	Sandstone; yields are related to thickness and permeabililty
	Eau Claire Fm	Dolomite, sandstone, and shale; small yields may be possible from fractures
	Mt. Simon Fm	Sandstone; yields are related to thickness and permeability

Bedrock Surface Topography

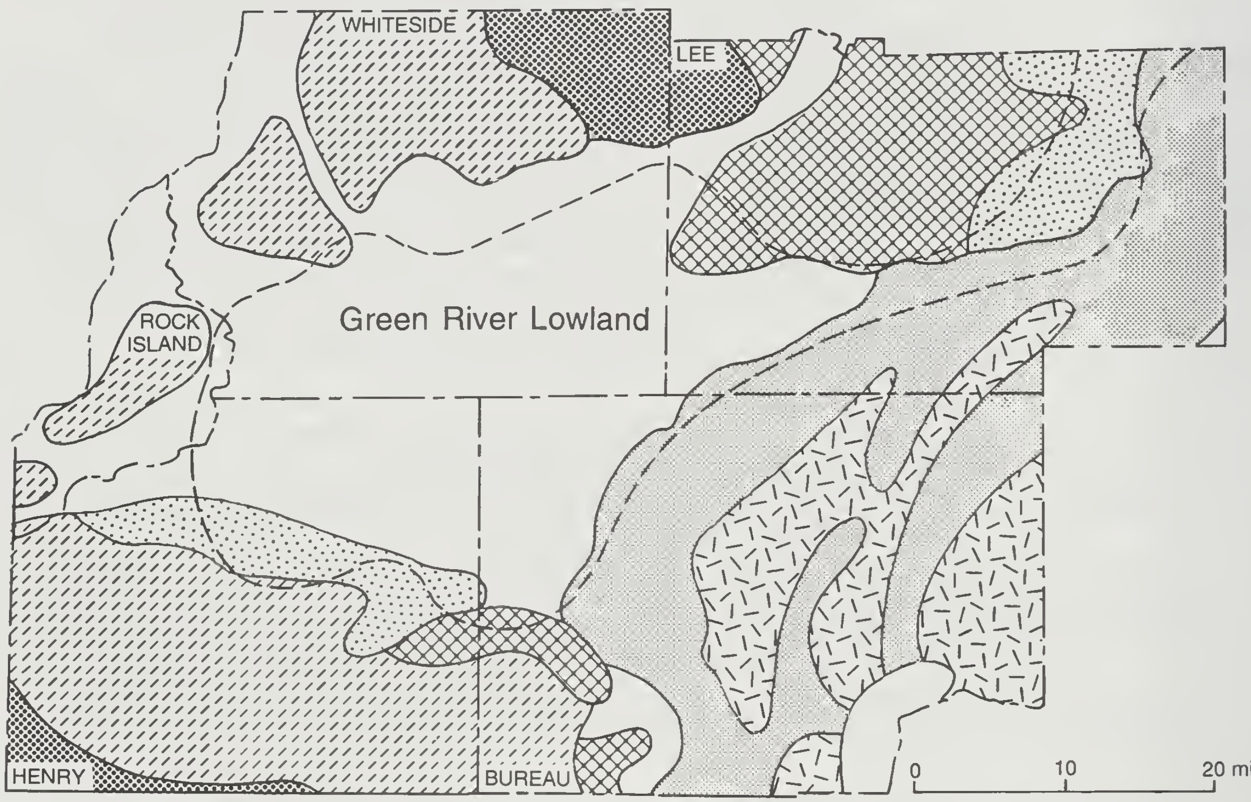
The map of the bedrock topography of the Green River Lowland and adjacent bedrock valleys (plate 1) is modified from Horberg (1950) using the information from water well records. The principal feature of the bedrock surface is the system of deeply incised bedrock valleys and tributaries. The bedrock valleys pertinent to this study are the Princeton, Paw Paw, and Rock (plate 1).

The Princeton Bedrock Valley trends northwest to southeast across the Green River Lowland in Whiteside, Henry, and Bureau Counties. It extends beyond the Lowland northwestward into Rock Island County and southeastward to southeastern Bureau County, where it joins the valley of the Illinois River. The bedrock elevation along the thalweg is about 450 feet where the valley enters the Green River Lowland from the northwest. It declines to an elevation of about 400 feet in south-central Whiteside County and to less than 350 feet in central Bureau County where the valley leaves the Lowland. The thalweg elevation ranges below 350 feet from the confluence with the Paw Paw Bedrock Valley on into southeastern Bureau County. Bedrock elevations of 337 to 396 feet (plate 1) were determined by reversed seismic profiling near the Illinois River valley in the southeast corner of Bureau County.

The Paw Paw Bedrock Valley trends northeast to southwest near the southeast edge of the Green River Lowland in Lee and Bureau Counties. It connects with the Princeton Bedrock Valley in central Bureau County and with the Rock Bedrock Valley in eastern Lee County. The bedrock elevation along the thalweg declines from about 450 feet in Lee County to about 350 feet at its confluence with the Princeton Bedrock Valley.

The Rock Bedrock Valley is a northeastward, upstream continuation of the Paw Paw Bedrock Valley. It bifurcates around a bedrock high in eastern Lee County. The main channel appears to lie on the northwestern and western sides of this bedrock high. Bedrock elevation along the thalweg of the main channel is about 450 feet; bedrock elevation in the side channel ranges from 450 to 500 feet.

The configuration of the deeper parts of the bedrock valley system is not very well known because few water wells are drilled into bedrock. Horberg (1950) contoured the bedrock valleys by extending contour lines upgradient to accommodate the lowest known elevation in the valley. However, a closed depression in the floor of the Princeton Bedrock Valley at the west edge of the Green River Lowland shows the valley floor is not uniformly graded. A test hole drilled by the U.S. Army Corps



HOLOCENE AND WISCONSINAN
Cahokia Alluvium, Parkland Sand, and Henry Formation combined; alluvium windblown sand, and sand and gravel.

WISCONSINAN
Peoria Loess and Roxana Silt combined; windblown silt more than 6 m (20 ft) thick.

Equality Formation; silt, clay, and sand in glacial and slack-water lakes.

Moraine / Ground moraine — Wedron Formation; glacial till with some sand, gravel, and silt.

WISCONSINAN AND ILLINOIAN
Winnebago and Glasford Formations combined; glacial till with some sand, gravel, and silt; age assignments of some units are uncertain.

ILLINOIAN
Glasford Formation; glacial till with some sand, gravel, and silt.

Figure 5 Quaternary deposits of the Green River Lowland area (Lineback 1981).

of Engineers bottomed out at an elevation 360 feet in sand and gravel. Using seismic refraction techniques, McGinnis and Heigold (1974) measured a bedrock elevation of 340 feet at the test-hole site. They mapped an elongate, closed depression in the bedrock surface of less than 350 feet in elevation by extending seismic profiles from the site. This is the first documented presence of such a depression in a bedrock valley in Illinois. The bedrock valleys in the Green River Lowland study area may have other closed depressions not yet identified because of the lack of subsurface data.

The bedrock uplands in the study area are formed by strata ranging in age from Cambrian through Pennsylvanian. Rocks of Silurian age and older form the bedrock surface in the Lee, Whiteside, and Rock Island County parts of the study area. The uplands in the Bureau and Henry County parts of the study area consist of strata that are Pennsylvanian in age. Elevations of the upland bedrock surface range between 550 and 750 feet, with the higher elevations more common in Lee County.

Quaternary Deposits

Type and distribution The Quaternary deposits in the Green River Lowland (fig. 5) include glacial till, outwash sand and gravel, lacustrine sediments, and eolian deposits. Till is an unsorted and unstratified mixture of clay, silt, sand, gravel, and boulders deposited directly from a glacier. Outwash consists mainly of bedded sand and gravel deposited by glacial meltwater streams. It may occur in the form of valley train outwash confined by valley walls into a long, narrow deposit, or spread over a large area as a flat or gently sloping deposit called an outwash plain. Lacustrine sediments are deposited in the relatively quiet water of a lake. Eolian sediments are deposited by the wind. Other types of deposits present include accretion gley, colluvium, and floodplain sediments. These are more limited in thickness and extent than is the glacial drift.

Thickness of the glacial drift ranges from zero to more than 300 feet (Piskin and Bergstrom 1975). The drift is thinnest where it overlies the bedrock uplands and thickest within the bedrock valleys. The Lowland surmounts a bedrock high in central Lee County, an area of thin drift, before it intersects the Rock Bedrock Valley in northeastern Lee County. Drift thickness along the bedrock valley system adjacent to the Green River Lowland ranges from about 300 feet in the Princeton Bedrock Valley to more than 400 feet in the Paw Paw and Rock Bedrock Valleys where the Wisconsinan terminal moraine adds to the drift thickness. The drift thicknesses determined for this study did not differ significantly from those mapped by Piskin and Bergstrom (1975).

Figure 6 presents a schematic diagram of the sequence of Quaternary sediments in the Green River Lowland study area. The oldest glacial deposits in the area belong to the Banner Formation (Horberg 1950, 1953, Horberg et al. 1950). These pre-Illinoian sediments consist mostly of outwash sands and gravels correlative with the Sankoty Sand Member. The outwash is found in the bedrock valleys. The outwash grades to fine grained sediments in small, localized areas within a valley or near valley walls. The fine textured sediments of the Glasford Formation (Illinoian) overlie the Banner Formation. The contact between these two formations is not well defined in the study area. Through much of the Green River Lowland, the Glasford Formation includes lacustrine sediments. Thickness of the Glasford increases near the margins of the Lowland where till and outwash sand and gravel are interbedded with the lacustrine deposits. Buried soil, silt beds, or organic deposits that help identify the top of the Glasford are not very common inside the Lowland. Surficial outwash deposits assigned to the Henry Formation of Wisconsinan age (Willman and Frye 1970) overlie the Glasford Formation. The distribution and thickness of the Henry Formation are fairly well known over most of the Lowland. Bedded sand, silt, and clay associated with a lacustrine depositional environment define the Equality Formation. This unit is a surficial deposit in the study area and occurs near the edge of the Lowland and at its extreme northeastern end. The Peoria Loess, an eolian deposit of silt and very fine grained sand, occurs as a relatively thin veneer on the present landscape near the periphery of the west half of the Lowland. Sediments of Wisconsinan and Holocene age are found as sand dunes (Parkland Sand) and along drainageways (Cahokia Alluvium).

Hydraulic properties Groundwater movement through the Quaternary deposits of the study area is generally influenced by the nature, extent, and thickness of the various types of lithologic units. The rate of movement is determined by the hydraulic conductivity of the material through which the water moves and by the prevailing hydraulic gradient. For unlithified formations, the magnitude of hydraulic conductivity usually depends on the grain size distribution of sedimentary particles.

Hydraulic conductivity of the Quaternary deposits in the study area can be estimated from values determined for certain associations of sediment grain sizes. These values are applied to similar

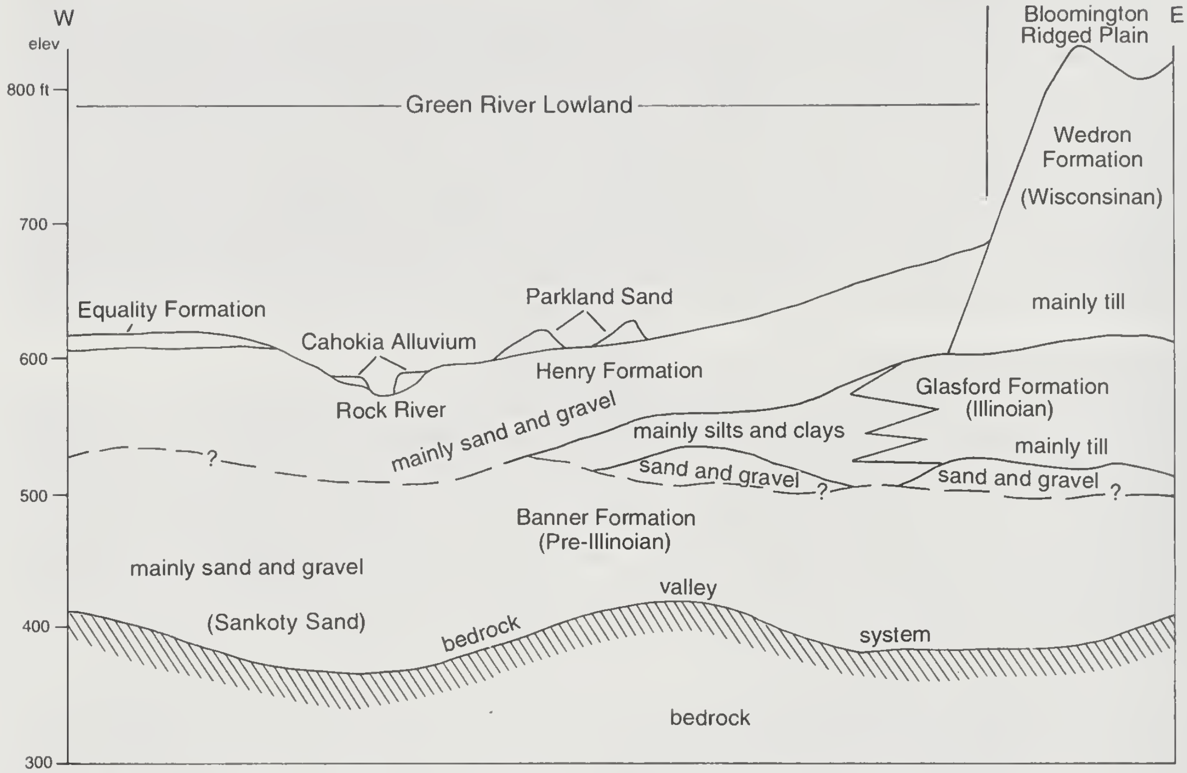


Figure 6 Schematic diagram of the sequence of Quaternary deposits, Green River Lowland area.

deposits as described in the lithologic logs of test holes or water wells. Walton (1970, p. 36) gives representative hydraulic conductivity values for various types of deposits as follows:

sand—100 to 3,000 gallons per day per foot squared (gpd/ft^2) (5×10^{-3} to 1×10^{-1} cm/s)
sand and gravel—200 to 5,000 gpd/ft^2 (9×10^{-3} to 2×10^{-1} cm/s)
gravel—1,000 to 15,000 gpd/ft^2 (5×10^{-2} to 7×10^{-1} cm/s)
clay, silt—0.001 to 2 gpd/ft^2 (5×10^{-8} to 9×10^{-5} cm/s)

Walton (1970, p. 239) also lists values for the hydraulic conductivity of drift aquitards for various locations in Illinois, differentiated by the relative quantities of clay, sand and gravel, and dolomite. The values range from 0.0046 gpd/ft^2 (2×10^{-7} cm/s) for a drift aquitard that is clay with some sand, gravel, and shaly dolomite to 1.60 gpd/ft^2 (8×10^{-5} cm/s) for one that is sand and gravel with some clay.

A detailed analysis of the volume of groundwater in storage and the water yielding capability of the drift aquifers in the study area was beyond the scope of this study. These analyses can be completed after the hydrostatic heads of the separate aquifers have been measured and aquifer parameters (e.g., hydraulic conductivity, transmissivity, storage coefficient, and specific yield) have been calculated.

ASSESSMENT OF GROUNDWATER RESOURCES

An assessment of groundwater resources describes the nature and occurrence (the hydrogeologic setting) of the resource of an area. Such an assessment provides a basis for evaluating existing development of the resource, resolving conflicts in groundwater use, and assessing the potential for increased use of the resource or the potential for contamination of the resource.

For this study, the Quaternary deposits in the Green River Lowland are divided into several hydrostratigraphic units (figs. 7, 8, and 9). These units are part of the Prairie Aquigroup (Visocky et al. 1985). The unconfined aquifer that occurs mainly in the surficial sands and gravels is herein named the Tampico aquifer. The sand and gravel found within the bedrock valleys in and adjacent to the Lowland (the Princeton, Paw Paw, and Rock Bedrock Valleys; plate 1) constitute aquifers

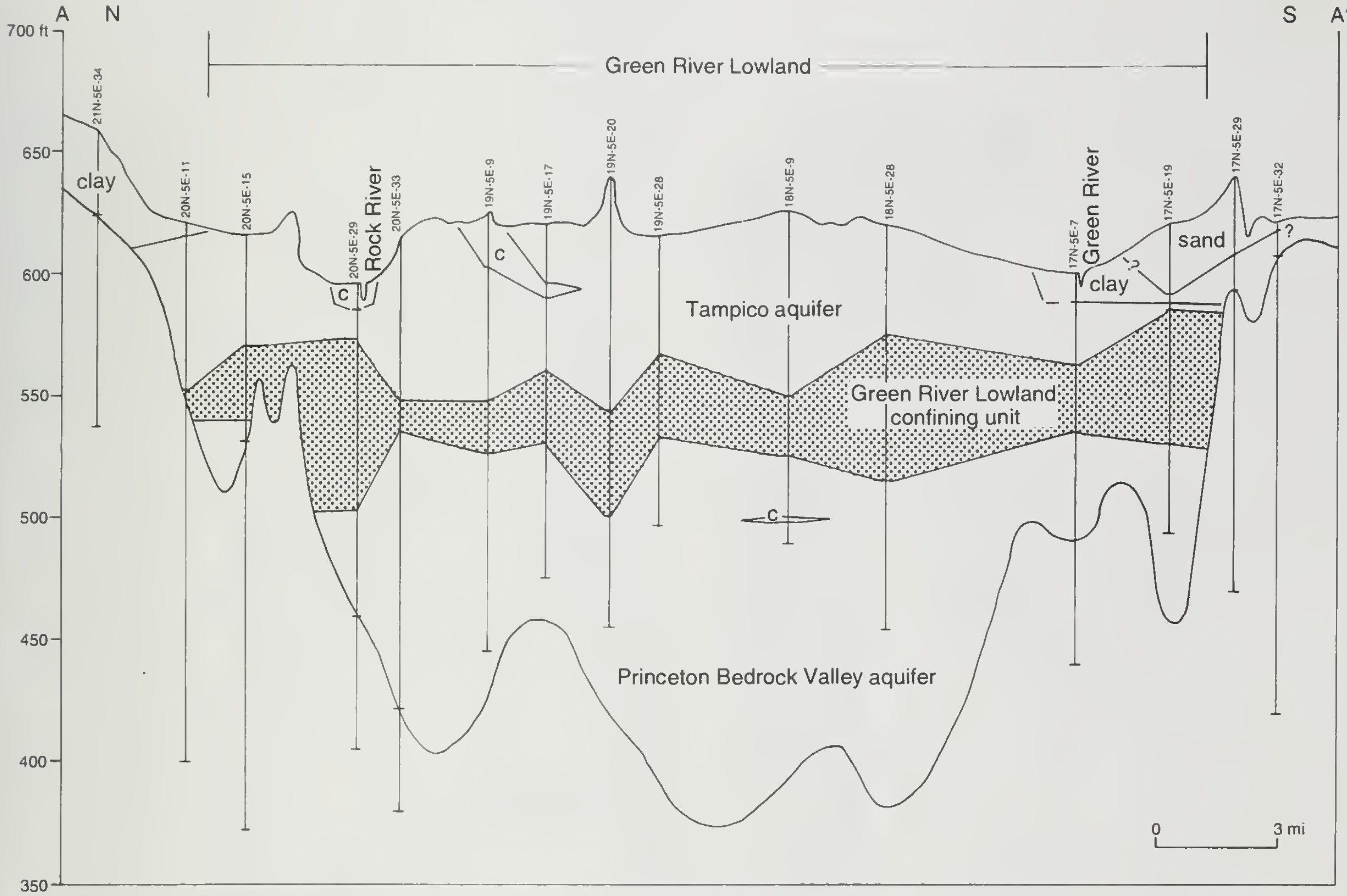


Figure 7 North–south hydrostratigraphic cross section, Green River Lowland area (line of cross section shown on plate 2).

herein named the Princeton, Paw Paw, and Rock Bedrock Valley aquifers. The fine textured sediments that separate the Tampico aquifer from the Princeton Bedrock Valley aquifer over most of the Lowland are herein combined and named the Green River Lowland confining unit. The bedrock valley aquifers adjacent to the Green River Lowland are discussed in this report because these aquifers are a significant groundwater resource in the area.

Tampico Aquifer

The Tampico aquifer is found over much of the Green River Lowland (plate 2). In most water well logs, it is described as sand although it is noted as fine sand in some logs and as sand and gravel in others. These surficial and near surface deposits are Wisconsinan in age and are assigned to the Henry Formation (Willman and Frye 1970). The Tampico aquifer also includes the Parkland Sand (Holocene) where these eolian sediments are saturated. Fine grained sediments (mostly lacustrine silts and clays) separate the Tampico aquifer from the Princeton Bedrock Valley aquifer, except in small areas of the Lowland.

Thickness of the surficial deposits containing the Tampico aquifer ranges from less than 10 feet to more than 100 feet (plate 2), but it is about 50 feet over much of the areal extent of the aquifer. However, some water well logs indicate that the Tampico aquifer (as well as the Princeton Bedrock Valley aquifer) may not be found in small areas within the Lowland. For example, the log for a water well located in Section 1, T19N, R4E, west of Prophetstown shows 215 feet of sandy clay from land surface to bedrock. The hydrostratigraphy, areal extent, and hydraulic relationship to the aquifer of relatively small areas such as this are not well understood from the data currently available.

The confining unit that separates the Tampico from the Princeton Bedrock Valley aquifer is missing in some areas of the Lowland. In these areas the two aquifers form one hydraulic unit. The predominant areas where this occurs are near the northwest edge of the Lowland, near the center of the Lowland in northeastern Henry County, and along the north-central edge of the Lowland in

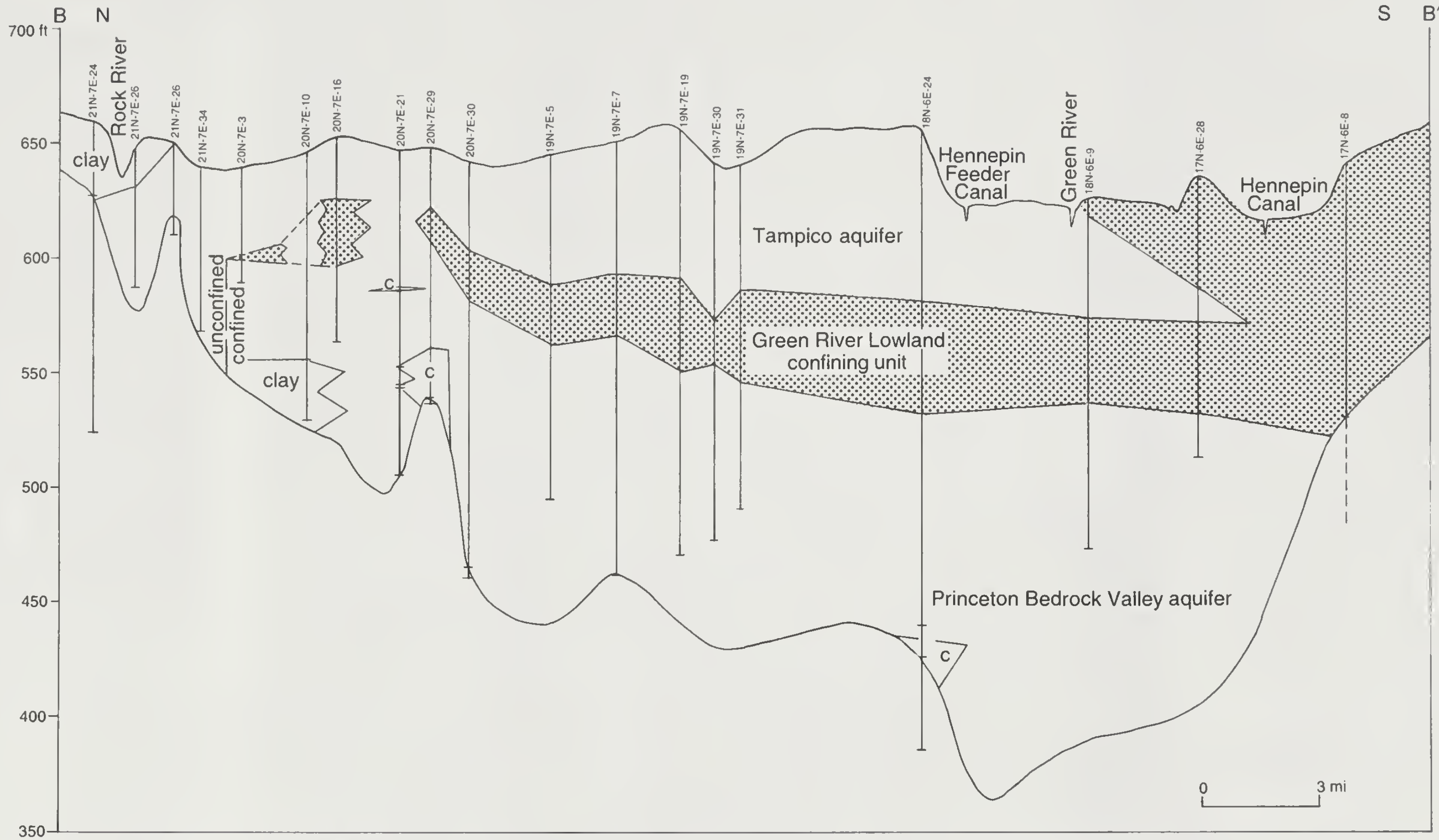


Figure 8 North–south hydrostratigraphic cross section, Green River Lowland area (line of cross section shown on plate 2).

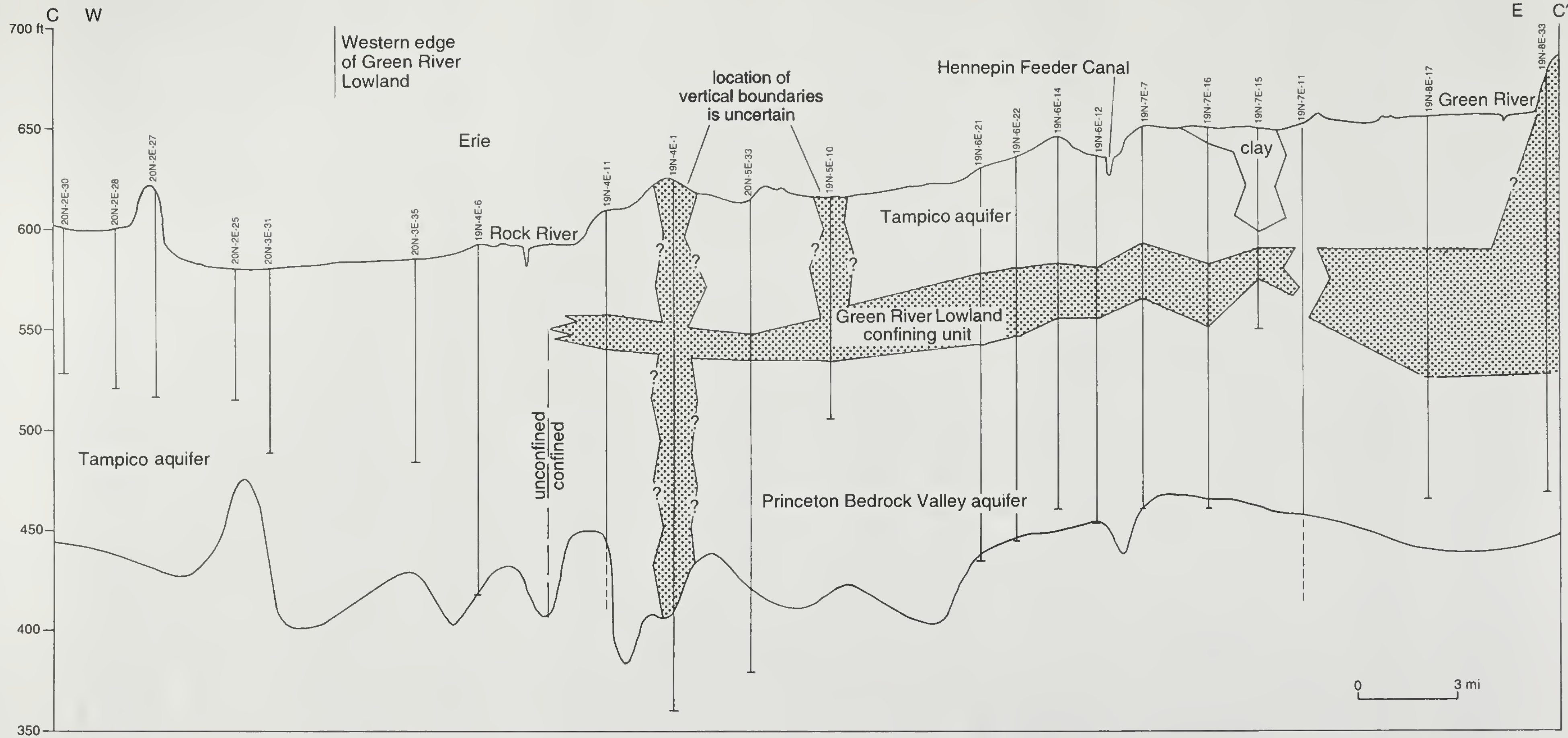


Figure 9 West–east hydrostratigraphic cross section, Green River Lowland area (line of cross section shown on plate 2).

the vicinity of Rock Falls. Smaller areas are found scattered across the eastern part of the Lowland. Wide variations in aquifer thickness affect groundwater movement and need to be considered in managing groundwater resources.

Walton (1970) gives a range for the hydraulic conductivity of sand as 100 to 3,000 gpd/ft^2. Multiplying this range of hydraulic conductivity by the aquifer thickness values gives a transmissivity range of 1,000 to more than 300,000 gpd/ft; transmissivities of 5,000 to 150,000 gpd/ft are probably more common. These transmissivity values indicate both a good potential yield of water to wells and a good sustained water yielding capability. Productivity of the aquifer is enhanced by direct recharge from precipitation and the possibility of induced recharge of surface water from the Rock and Green Rivers. Increased thickness where the Tampico aquifer merges with the underlying Princeton Bedrock Valley aquifer also enhances productivity.

Water levels reported on water well records show the Tampico aquifer is under unconfined (water table) conditions. These data suggest a downward hydraulic gradient from the Tampico aquifer to the deeper Princeton Bedrock Valley aquifer. Variation in precipitation causes variation in recharge, which affects the amount of water available for use from the Tampico aquifer.

There is great potential for groundwater contamination of the Tampico aquifer because it directly underlies the land surface. Where the two sand and gravel aquifers are connected, the shallower aquifer provides an avenue for pollution to move into the deeper aquifer and subsequently into the Silurian bedrock.

Princeton Bedrock Valley Aquifer

The Princeton Bedrock Valley aquifer occupies the Princeton Bedrock Valley, which trends northwest to southeast across the Green River Lowland (plate 1). The aquifer consists of sand and interbedded sand and gravel directly overlying Silurian and Pennsylvanian bedrock. Horberg et al. (1950) note the similarity of these deposits to those at the Sankoty well field north of Peoria. They describe the Sankoty Sand (pre-Illinoian) as a medium grained sand, but observe that it can vary from fine grained, silty sand to coarse grained, gravelly sand. This variability in grain size is also found in the study area.

The elevation of the top of the Princeton Bedrock Valley aquifer declines from about 600 feet in Rock Island County to 500 to 550 feet within the Green River Lowland and central Bureau County. It continues to decline to about 450 feet near the Illinois River valley in southeastern Bureau County (plate 3). In southeastern Bureau County, Big Bureau Creek has incised its valley into the aquifer. Along the margins of the bedrock valley in the Lowland, the top of the aquifer is at an elevation of approximately 600 feet.

The upper boundary of the Princeton Bedrock Valley aquifer is defined by the overlying confining unit. Because the contact between the Banner and Glasford Formations is not well defined, the Princeton Bedrock Valley aquifer most likely includes basal sands and gravels of the Glasford Formation. The Princeton Bedrock Valley aquifer merges with the Tampico aquifer where the aquitard between them is missing.

Thickness of the Princeton Bedrock Valley aquifer (plate 4) was determined from water well records. The boreholes for some wells bottomed out in bedrock and the records show the entire thickness of the drift. In the deeper parts of the Princeton Bedrock Valley, water wells typically are not drilled to bedrock. The potential thickness of the aquifer was calculated by subtracting the elevation of the bedrock surface, as interpolated from the bedrock topography map (plate 1), from the elevation of the top of the aquifer (plate 3). Calculating the potential thickness of the aquifer in this manner partially surmounts the problem of the small number of water wells drilled to bedrock.

Thickness of the Princeton Bedrock Valley aquifer ranges from less than 50 feet along the margins of the bedrock valley to more than 200 feet in southwestern Whiteside County, where the closed depression in the bedrock surface is located. The aquifer is typically 100 to 150 feet thick within and beyond the Green River Lowland. In small, isolated areas within the bedrock valley, fine grained sediments are found in place of the sand and gravel of the Princeton Bedrock Valley aquifer.

Aquifer transmissivity, estimated to range from less than 5,000 to more than 1,000,000 gpd/ft, was determined using hydraulic conductivities for sand/sand and gravel of 100 to 5,000 gpd/ft^2 (Walton 1970) and thicknesses of 50 to 200 feet. These hydraulic characteristics indicate that the thicker parts of this aquifer have both a greater potential yield to water wells and sustained water yielding

capability than does the Tampico aquifer. Productivity of the Princeton Bedrock Valley aquifer, where it merges with the overlying Tampico aquifer, is enhanced because of greater saturated thickness, more direct recharge from precipitation, and the possibility of induced recharge from surface water.

The hydraulic relationship of the Princeton Bedrock Valley aquifer to the underlying Silurian dolomite is not well known. Available data from water well records suggest a downward hydraulic gradient from the sand and gravel aquifer into bedrock. The data also indicate a downward gradient into the Princeton Bedrock Valley aquifer from the overlying Tampico aquifer.

Paw Paw Bedrock Valley Aquifer

The Paw Paw Bedrock Valley aquifer occupies the Paw Paw Bedrock Valley, which parallels the southeast border of the Green River Lowland (plate 1). The aquifer consists of sand and interbedded sand and gravel directly overlying bedrock of Ordovician and Silurian age. Horberg et al. (1950) note that these deposits occupy a similar stratigraphic position to those at the Sankoty well field north of Peoria.

The top of the Paw Paw Bedrock Valley aquifer commonly ranges from an elevation of 500 to 550 feet but locally may rise to approximately 600 feet (plate 3). Thickness of the Paw Paw Bedrock Valley aquifer (plate 4) was determined from water well records in the manner described for the Princeton Bedrock Valley aquifer. The aquifer may include sand and gravel of the Glasford Formation in some areas, as is the case with the Princeton Bedrock Valley aquifer. Thickness of the Paw Paw Bedrock Valley aquifer ranges from about 100 to 150 feet, but it decreases to less than 50 feet along the margins of the bedrock valley. The aquifer is more than 150 feet thick in some small, isolated areas and at its confluence with the Princeton Bedrock Valley aquifer.

Aquifer transmissivity, estimated to range from less than 5,000 to about 750,000 gpd/ft, was determined using hydraulic conductivities for sand/sand and gravel of 100 to 5,000 gpd/ft^2 (Walton 1970) and thicknesses of 50 to 150 feet. These hydraulic characteristics indicate that this aquifer has a good potential to yield water to wells and a good sustained water yielding capability.

The hydraulic relationship of the Paw Paw Bedrock Valley aquifer to the underlying Silurian dolomite is not well known. Available data from water well records suggest a downward hydraulic gradient from the sand and gravel aquifer into bedrock. For the Ordovician rocks, Visocky et al. (1985) indicate a downward hydraulic gradient from the Paw Paw Bedrock Valley aquifer into bedrock.

Rock Bedrock Valley Aquifer

The Rock Bedrock Valley aquifer trends north to south across the northeastern end of the Green River Lowland (plate 1). The aquifer consists of sand and interbedded sand and gravel directly overlying mostly Ordovician and Cambrian bedrock in northeastern Lee County. The top of this aquifer typically is at an elevation of 500 to 550 feet, but it approaches 600 feet near the margins of the bedrock valley. The aquifer may include sand and gravel of the Glasford Formation in some areas, as is the case with the Princeton Bedrock Valley aquifer.

Thickness of the Rock Bedrock Valley aquifer (plate 4) was determined from water well records in the manner described for the Princeton Bedrock Valley aquifer. Thickness of the Rock Bedrock Valley aquifer ranges from less than 50 feet along the margins of the bedrock valley to between 100 and 150 feet in the center of the bedrock valley. It is locally greater than 150 feet thick.

Aquifer transmissivity, estimated to range from less than 5,000 to about 750,000 gpd/ft, was determined using hydraulic conductivities for sand/sand and gravel of 100 to 5,000 gpd/ft^2 (Walton 1970) and thicknesses of 50 to 150 feet. Because of these hydraulic characteristics, this aquifer has a good potential to yield groundwater to wells and a good sustained water yielding capability. Visocky et al. (1985) indicate that there is a downward hydraulic gradient from the Rock Bedrock Valley aquifer into bedrock.

Green River Lowland Confining Unit

Fine grained sediments separate the Tampico aquifer from the Princeton Bedrock Valley aquifer over most of the Green River Lowland (plate 5). These sediments are missing in southwestern Whiteside and northeastern Henry Counties. In the main part of the Lowland, thickness of the aquitard typically ranges from 25 to 50 feet. Thickness may locally increase to about 75 feet. The aquitard consists predominantly of thinly bedded lacustrine silts and clays with some very thin beds of very fine sand. The aquitard commonly is 75 to 125 feet thick in southwestern Lee County, but

the thickness increases to as much as 200 feet in T20N, R8E. In this part of the Lowland, the aquitard includes till and some thin layers of sand or sand and gravel along with the lake bottom sediments.

The elevation of the top of the confining unit (plate 6) typically ranges between 550 and 600 feet over much of the Green River Lowland. The elevations range from 625 to 650 feet near the margins of the Lowland.

Textural variations of the confining unit result in variable hydraulic conductivities. The quantity of water moving through the confining unit where only fine grained lacustrine sediments are present is likely to be much smaller than that where the interval consists of a mixture of silt and clay, till, and sand and gravel.

POTENTIAL FOR GROUNDWATER CONTAMINATION

The disposal of various kinds of waste on the land surface, the burial of waste at shallow depths, accidental spills of contaminants, and the use and misuse of agricultural chemicals may cause groundwater contamination. The potential for groundwater contamination is partly determined by the thickness, areal extent, and hydraulic characteristics of the types of earth materials present at and near the land surface. The map of the potential for groundwater contamination in the Green River Lowland area (plate 7) uses a combination of the stratigraphic position of various geologic materials and their respective hydraulic conductivities to estimate the relative hydrogeologic potential for contamination of aquifers.

The relative contamination potential is ranked by categories identified by a combination of letters and numbers. Letters A, B, and C designate geologic sequences with greater susceptibility to contamination (Berg et al. 1984). These sequences are as follows: A—sand and gravel or permeable bedrock at land surface; B—sand and gravel within 20 feet of land surface, often overlain and underlain by low permeability materials; and C—sand and gravel or permeable bedrock between 20 and 50 feet of land surface. Numbers are used within these three categories to identify distinct geologic sequences having a similar potential for contamination. The letters D, E, F, and G designate geologic sequences with lower susceptibility to contamination. These sequences are as follows: D—at least 50 feet of sandy till; E—at least 50 feet of silty or clayey till; F—relatively impermeable bedrock within 20 feet of land surface, commonly overlain by low permeability glacial drift; and G—relatively impermeable bedrock within 20 to 50 feet of land surface, overlain by low permeability till or other fine grained sediments. Category E was expanded, on the basis of data reviewed for this study, from one to two geologic sequences (plate 7) to more adequately describe the contamination potential represented by this category. Category E1 represents uniform, relatively impermeable silty or clayey till at least 50 feet thick with thick, interbedded sand and gravel at depths of greater than 50 feet. Category E2 is category E of Berg et al. (1984). It represents uniform, relatively impermeable silty or clayey till at least 50 feet thick with no evidence of thick, interbedded sand and gravel at depths of greater than 50 feet.

The pattern of areas of equal potential for groundwater contamination shown on plate 7 reflects the fairly uniform sequence of geologic materials in the Green River Lowland. This sequence is mostly surficial sand overlying lacustrine silts and clays with underlying sand and gravel. This geologic setting is reflected by the broad areas mapped as A2 and AX, which indicate a high potential for groundwater contamination. Berg et al. (1984) define A2 as thick, permeable sand and gravel within 20 feet of land surface; and AX as alluvium (a sand, gravel, silt, and clay mixture) of variable composition and thickness along streams.

Plate 7 shows the general relationship between the geology and the potential for groundwater contamination within the study area. This map does not replace the detailed studies needed to determine the groundwater contamination potential of activities at specific locations.

RECOMMENDATIONS FOR FURTHER STUDY

The glacial drift aquifers in the Green River Lowland constitute a groundwater resource that is vital to this region as a source of water for domestic, municipal, industrial, and irrigation supply. This study advanced the understanding of the hydrogeologic setting of these aquifers.

Questions remain, however, about the nature and occurrence of the region's groundwater in the drift aquifers—particularly in the three bedrock valleys where few water wells penetrate the entire thickness of the aquifer. Additional investigation will help define the groundwater flow systems within

the glacial drift and identify hydraulic relationships between the drift and bedrock. This information will strengthen the basis for developing and managing the groundwater resources of the region. Controlled test drilling and additional geophysical surveys will better define the configuration of the bedrock surface and the hydrogeologic characteristics and areal extent of the bedrock valley aquifers. Properly constructed piezometers should be installed using accepted standard practices to maximize the accuracy of water level data.

These data are used to define groundwater flow within the aquifers, the movement of groundwater along horizontal and vertical gradients from recharge to discharge areas, the hydraulic relationships between the two drift aquifers and between the drift aquifers and the bedrock, and the interactions between groundwater and surface water. Interactions between groundwater and surface water most likely are significant along reaches of the Rock and Green Rivers in the Green River Lowland, as well as along Big Bureau Creek in southeastern Bureau County. Additional data on the subsurface stratigraphy will better define the characteristics and areal extent of the confining unit between the two drift aquifers, as well as the location and extent of areas where fine grained sediments apparently extend from land surface to bedrock.

The hydrogeologic setting of the drift aquifers in the Wedron (Wisconsinan) and Glasford (Illinoian) Formations within the Bloomington Ridged Plain requires additional investigation so that the hydraulic relationships between these drift aquifers, as well as those in the Green River Lowland and the Bloomington Ridged Plain, can be analyzed. Data on aquifer properties, stratigraphy, and hydrostatic head are necessary for computer modeling of groundwater flow systems and for successful management of the groundwater resources.

ACKNOWLEDGMENTS

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The cooperation of ISWS is appreciated. The ISWS test drilling under the direction of Steve Burch provided an opportunity to look at Quaternary sediments at 22 sites in Whiteside, Henry, Lee, and Bureau Counties. Wayne Armstrong provided climatic data for 12 stations around the Green River Lowland in Whiteside, Lee, Henry, Bureau, and Rock Island Counties.

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Appendix Distribution of data points across the Green River Lowland. Points represent the water wells used for or referred to in this report. Well log information is on file at the Illinois State Geological Survey.

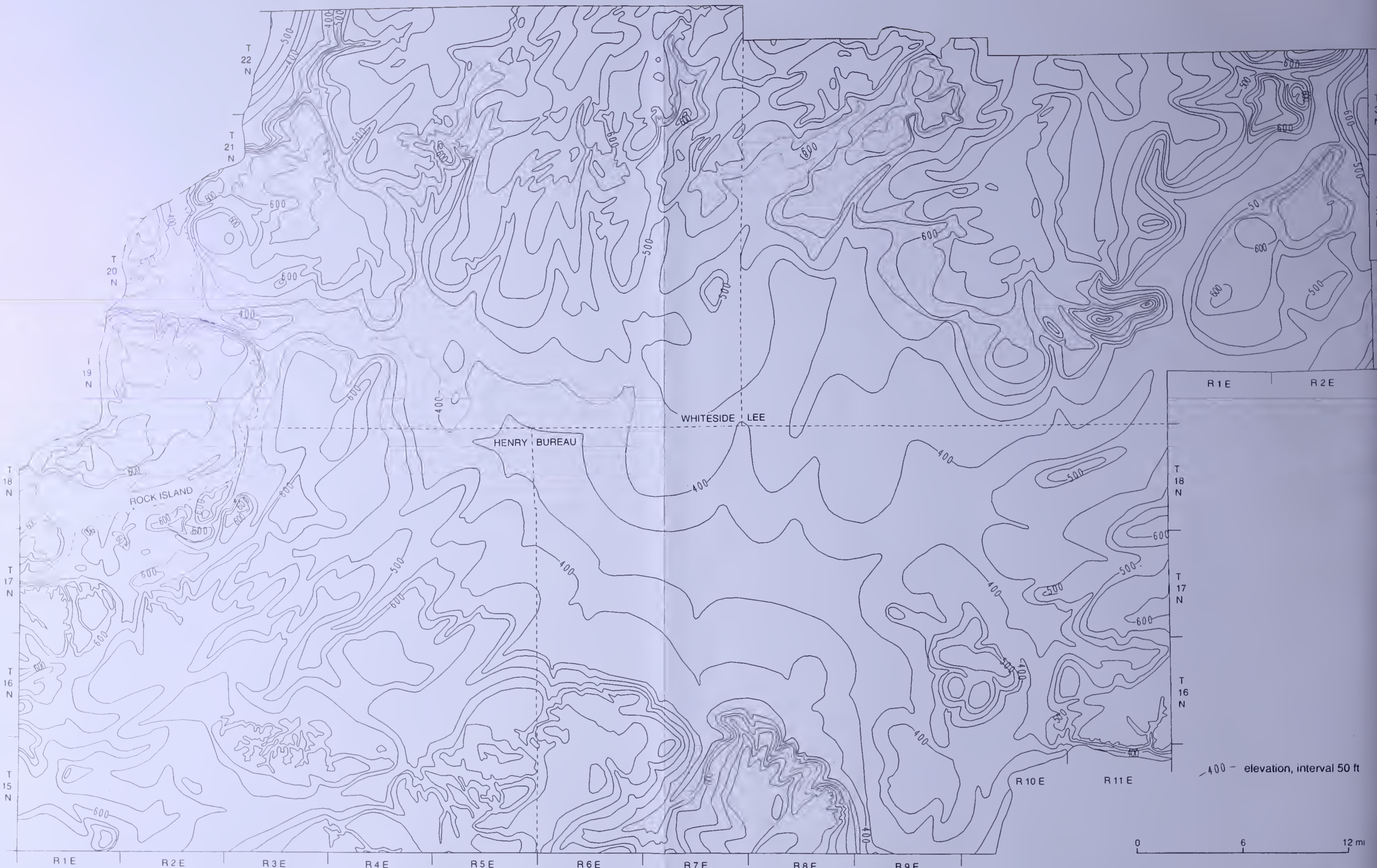


Plate 1 Bedrock surface elevation, Green River Lowland area.

Plate 2 Thickness of the sand and gravel containing the Tampico Aquifer, Green River Lowland area (lines of cross sections A–A′, B–B′, and C–C′ are shown).

WHITESIDE
LEE
T 39 N
T 38 N
T 37 N
R 1 E
R 2 E
T 18 N
T 17 N
T 16 N
R 10 E
R 11 E
R 7 E
R 8 E
R 9 E
600
500
400
400 — elevation, interval 50 ft
0
6
12 mi

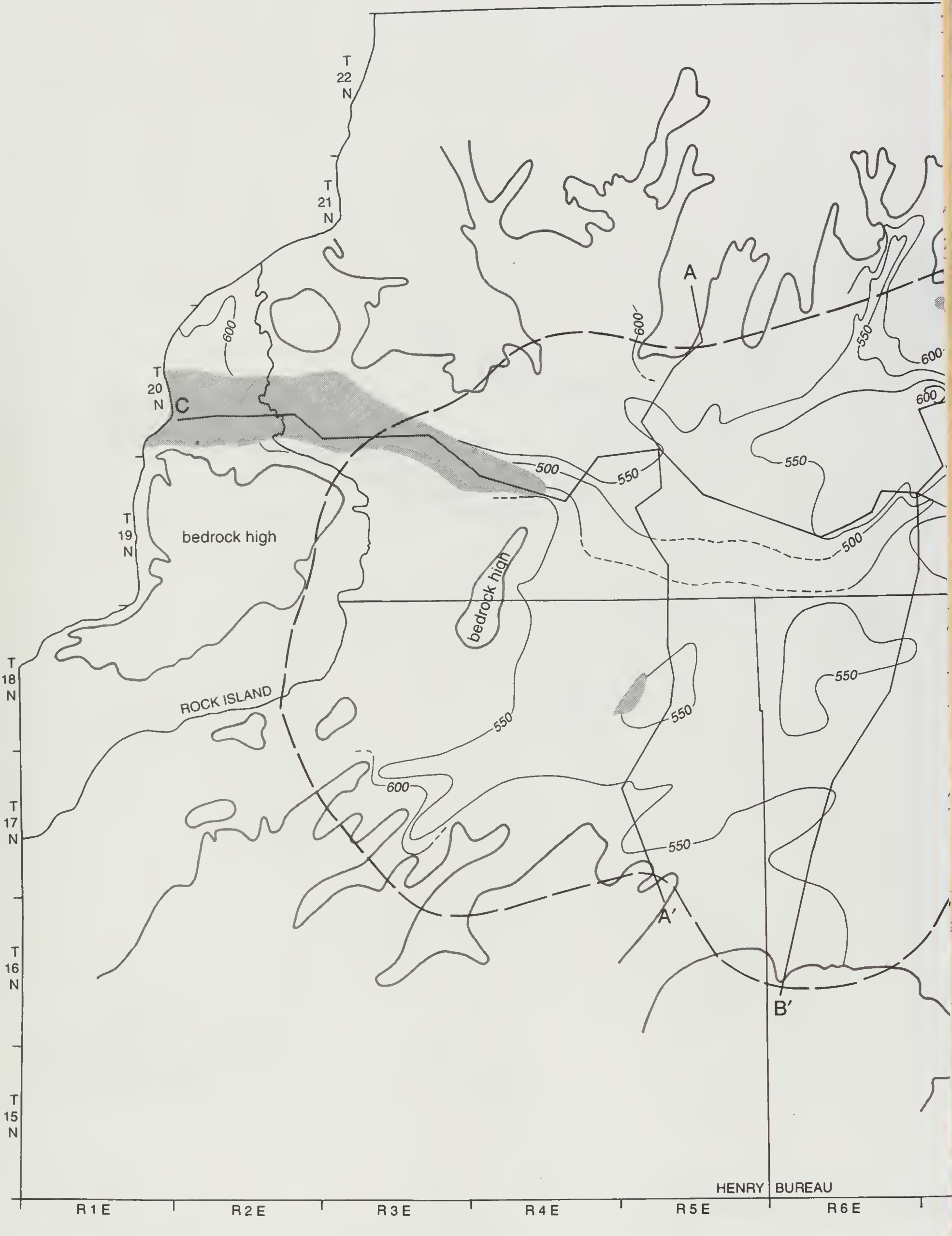


Plate 3 Elevation of the top of the bedrock valley aquifers, Green River Lowland area (lines of cross sections A–A′, B–B′, and C–C′ are shown).

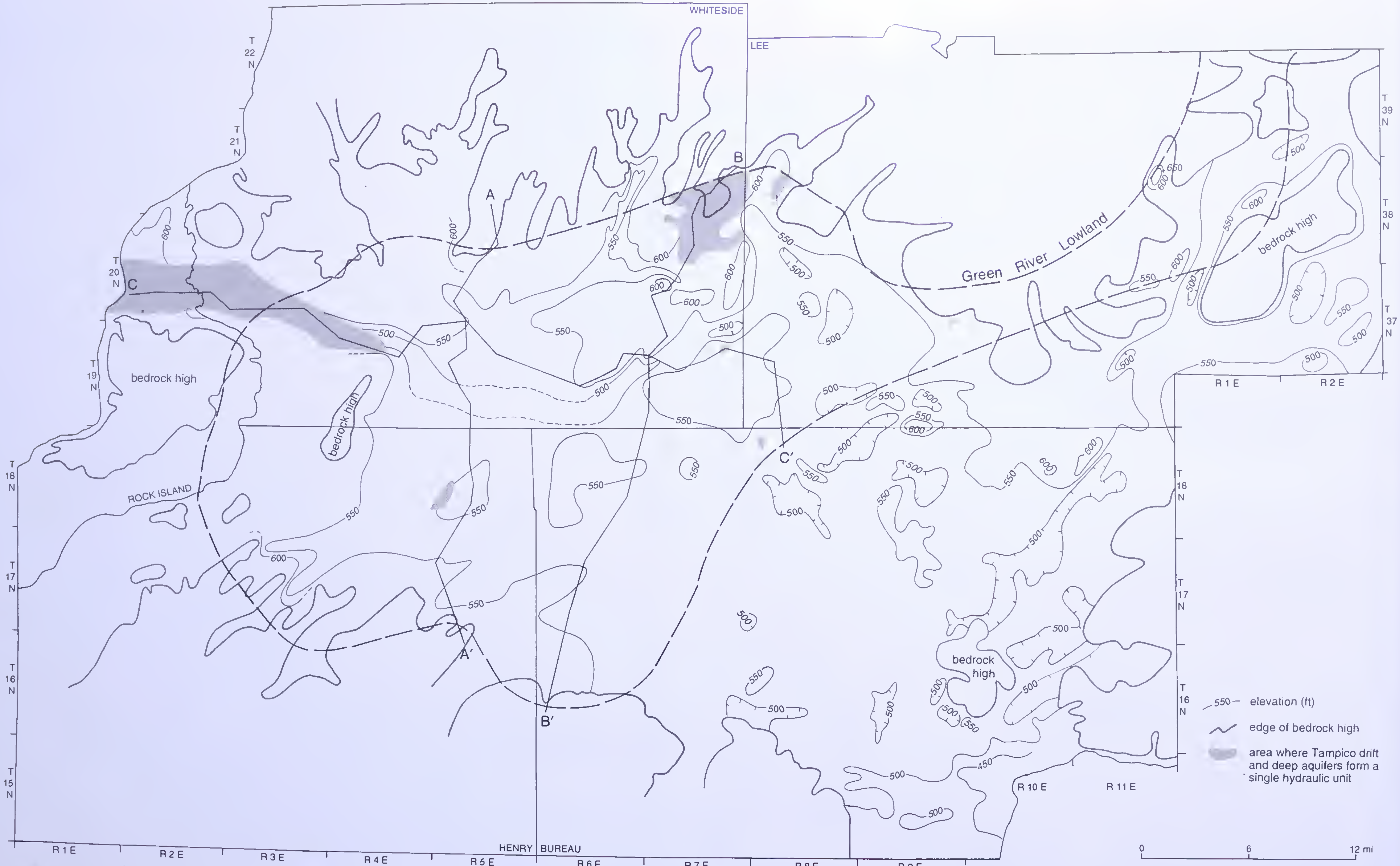


Plate 3 Elevation of the top of the bedrock valley aquifers, Green River Lowland area (lines of cross sections A–A′, B–B′, and C–C′ are shown).

Plate 4 Thickness/estimated thickness of the bedrock valley aquifers, Green River Lowland area (lines of cross sections A–A′, B–B′, and C–C′ are shown).

WHITESIDE
LEE
B
C'
Green River Lowland
bedrock high
bedrock high
T 39 N
T 38 N
T 37 N
T 18 N
T 17 N
T 16 N
R 1 E
R 2 E
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
550 elevation (ft)
edge of bedrock high
area where Tampico drift and deep aquifers form a single hydraulic unit
0
6
12 mi

Plate 5 Thickness of the confining unit, Green River Lowland (lines of cross sections A–A′, B–B′, and C–C′ are shown).

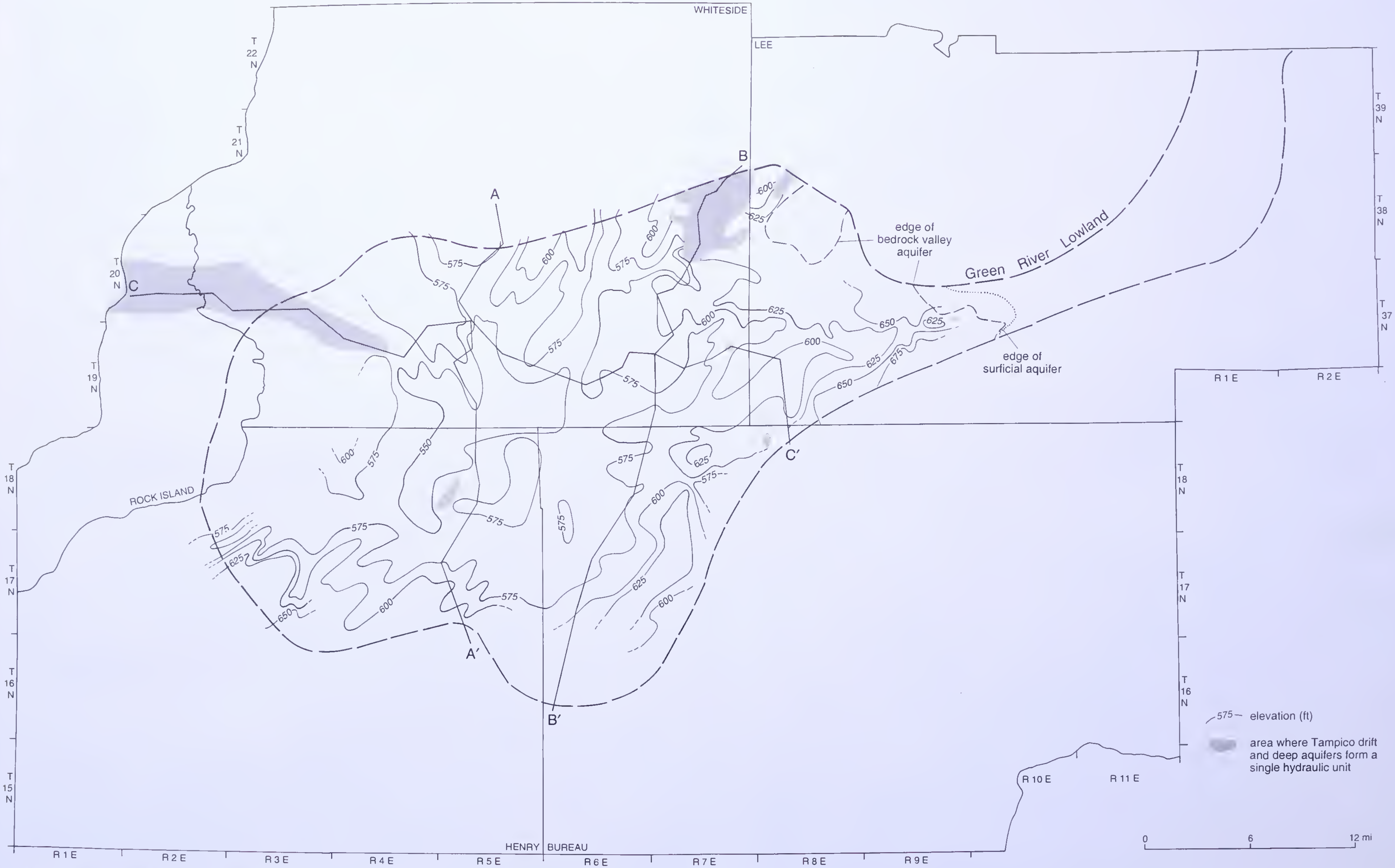
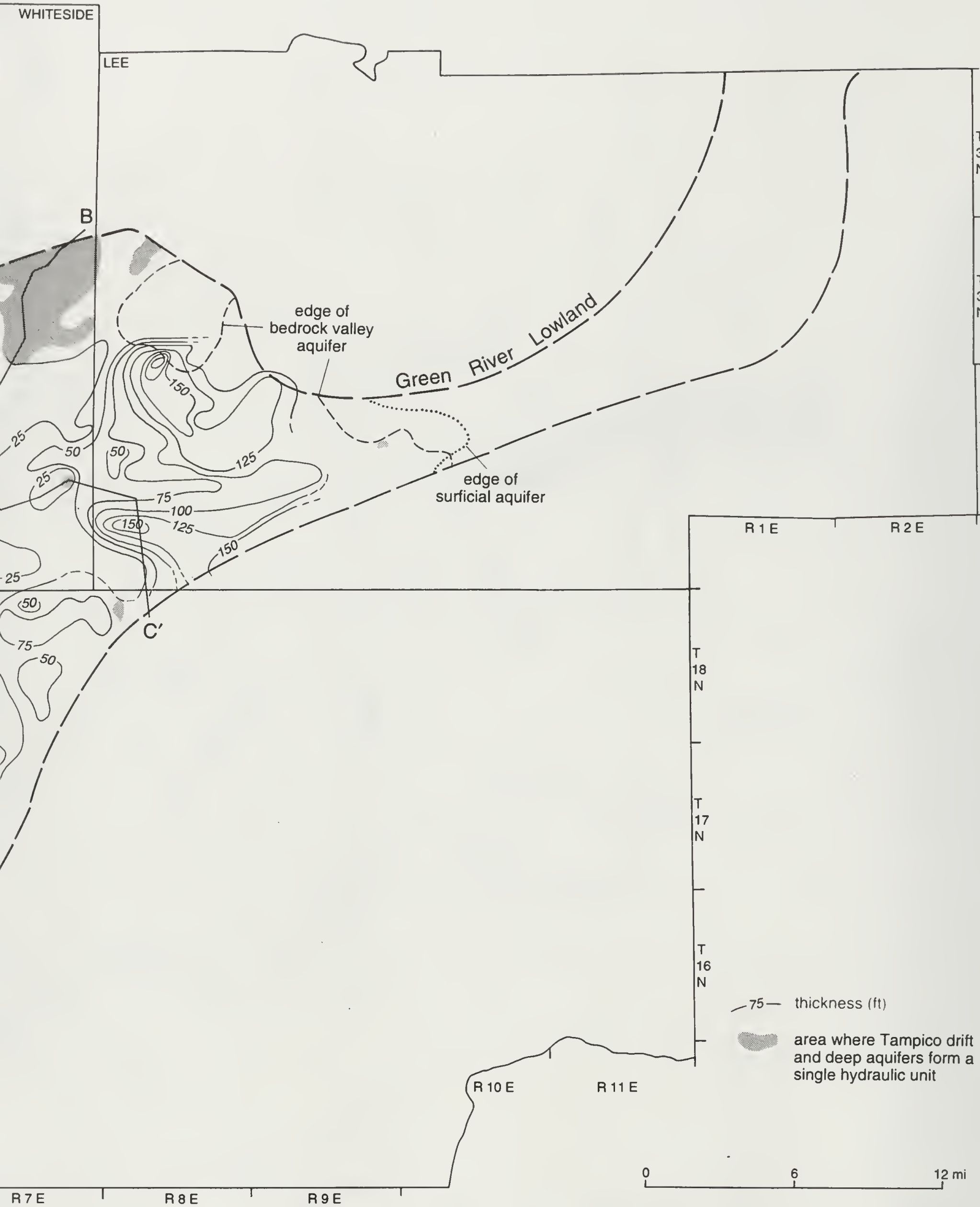


Plate 6 Elevation of the top of the confining unit, Green River Lowland (lines of cross sections A–A′, B–B′, and C–C′ are shown).

Plate 5 Thickness of the confining unit, Green River Lowland (lines of cross sections A–A′, B–B′, and C–C′ are shown).



WHITESIDE
LEE
B
edge of
bedrock valley
aquifer
Green River Lowland
150
125
100
75
50
25
edge of
surficial aquifer
C′
T 39 N
T 38 N
T 37 N
R 1 E
R 2 E
T 18 N
T 17 N
T 16 N
75 thickness (ft)
area where Tampico drift and deep aquifers form a single hydraulic unit
R 10 E
R 11 E
0
6
12 mi
R 7 E
R 8 E
R 9 E

Plate 7 Potential for groundwater contamination, Green River Lowland area (modified from the stack unit map of Berg et al. 1984). See text at right for explanation of symbols.

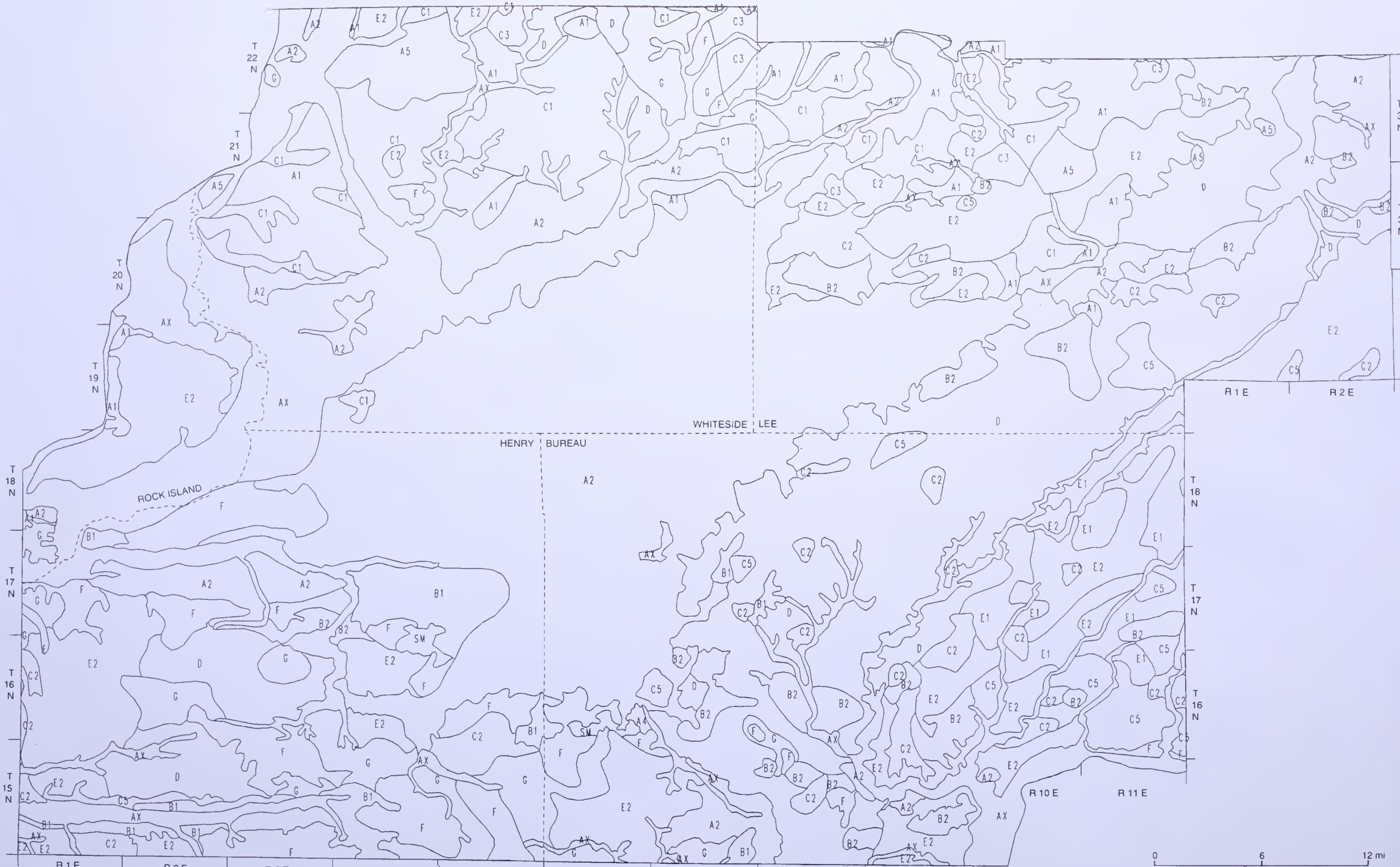


Plate 7 Potential for groundwater contamination, Green River Lowland area (modified from the stack unit map of Berg et al. 1984). See text at right for explanation of symbols.

A1 Permeable bedrock at or within 20 feet of land surface; overlain by variable materials

A2 Thick, permeable sand and gravel within 20 feet of land surface

A3 Permeable bedrock generally within 20 feet of land surface; where deeper, sand and gravel may be present

A4 Cemented sandstone within 20 feet of land surface; overlain by variable, relatively impermeable materials

A5 Permeable bedrock generally within 20 feet of land surface; overlain by variable materials, but mostly till

AX Alluvium, a mixture of gravel, sand, silt, and clay along streams; variable in composition and thickness

B1 Sand and gravel less than 20 feet thick; underlain by relatively impermeable till or bedrock

B2 Sand and gravel within 20 feet of land surface; overlain and underlain by till or other relatively impermeable materials, or underlain by bedrock

BX Map complex of permeable bedrock on ridges; underlain primarily by shale on slopes and valleys

C1 Permeable bedrock within 20 to 50 feet of land surface; overlain by till or other fine grained materials

C2 Sand and gravel within 20 to 50 feet of land surface; overlain and underlain by till or other relatively impermeable materials, or underlain by bedrock

C3 Permeable bedrock within 20 to 50 feet of land surface; overlain by till or other relatively impermeable materials; bedrock below 50 feet in places

C4 Cemented sandstone within 20 to 50 feet of land surface; overlain by till or other relatively impermeable materials

C5 Mostly till with discontinuous sand and gravel locally present within 50 feet of land surface

D Uniform, relatively impermeable sandy till at least 50 feet thick; no evidence of thick sand and gravel below 50 feet

E1 Uniform, relatively impermeable silty or clayey till at least 50 feet thick; thick sand and gravel below 50 feet

E2 Uniform, relatively impermeable silty or clayey till at least 50 feet thick; no evidence of thick sand and gravel below 50 feet

F Relatively impermeable bedrock at or within 20 feet of land surface; mostly overlain by till or other relatively impermeable materials

G Relatively impermeable bedrock within 20 to 50 feet of land surface; overlain by till or other relatively impermeable materials

SM Surface mined area